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NEIGHBORHOOD EMERGENCY HELP CENTER CONCEPT VALIDATION FINAL REPORT

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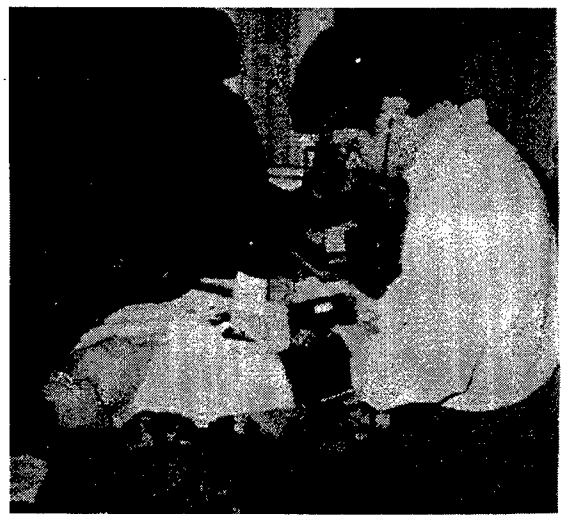

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This report describes the validation process for the Neighborhood Emergency Help Center (NEHC), performed as part of the national Domestic Preparedness (DP) Program. The report briefly describes the DP Program, the Biological Warfare Improved Response Program (BWIRP), and development of the BW Response Template. The report then presents the validation methodology used to test and evaluate the NEHC component of the template. Finally, the report provides the results of the NEHC validation testing process and recommendations for improving the NEHC design.

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Neighborhood Emergency Help Center

Concept Validation Final Report

Executive Summary

The Domestic Preparedness Program funds initiatives to improve the ability of U.S. communities to respond more effectively to terrorism by weapons of mass destruction. One of these initiatives is the Biological Weapons Improved Response Program. This program is developing a response template for cities to tailor and incorporate into their emergency response plans for use in case of an incident involving biological agents. The response template consists of a number of components, such as command and control, epidemiological investigation, and medical response.

The Neighborhood Emergency Help Center (NEHC) is an important component of the medical response portion of the template. The purpose of the NEHC is to serve as a temporary neighborhood clinic, providing triage and stabilization treatment to casualties close to their own homes. Under the NEHC concept, casualties requiring hospital care are transported to acute care centers. Those who are able to return home are given appropriate medications and instructions.

In order to validate the NEHC concept, a working group of emergency medical experts developed a detailed facility design, including staffing and casualty process flow. They also developed descriptions of a primary scenario, casualty profiles, and triage and treatment protocols. The primary scenario is a moderate-sized BW incident involving a non-contagious agent. These descriptions were entered into a verified simulation model of the NEHC design to predict performance. Performance was predicted in six areas: facility throughput, casualty cycle time, staff utilization, treatment efficacy, disposition of casualties and casualty data completeness.

NEHC performance was tested via a desktop exercise with an independent panel of emergency medical experts, and a live field test using trained medical staff and actors portraying casualties. The outcomes of these exercises were compared to the simulated performance to validate the design. The results of the testing provided evidence that the NEHC concept is valid. Future exercises to test the robustness of the NEHC concept under alternative scenarios and as part of the entire medical response portion of the template are planned.

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PREFACE

The work described in this report was authorized under the Domestic Preparedness Program. The work was started in March 1999 and completed in January 2000.

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The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorizing documents.

Section 1

1 Introduction

This report describes the validation process for the Neighborhood Emergency Help Center (NEHC), performed as part of the national Domestic Preparedness (DP) Program. The report briefly describes the DP Program, the Biological Warfare Improved Response Program (BWIRP), and development of the BW Response Template. The report then presents the validation methodology used to test and evaluate the NEHC component of the template. Finally, the report provides the results of the NEHC validation testing process and recommendations for improving the NEHC design.

1.1 Domestic Preparedness Program

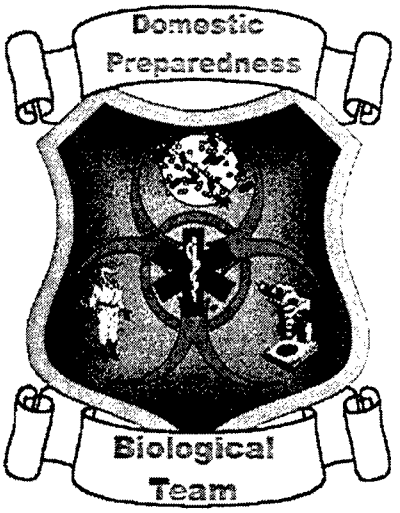
In response to growing concerns regarding domestic terrorism, the 104th Congress included in the National Defense Authorization Act for Fiscal Year 1997 a new, multiyear program to provide our nation's communities with training regarding emergency responses to weapons of mass destruction and to test ways to improve the responses of federal, state, and local agencies to emergencies involving biological and chemical weapons.

As a result of this act, the U.S. Army Soldier and Biological Chemical Command of the Department of Defense, in partnership with the Department of Health and Human Services, the Federal Emergency Management Agency, the Federal Bureau of Investigation, the Environmental Protection Agency, and the Department of Energy, developed the BWIRP. The purpose of the program is to identify, evaluate, and demonstrate the best practical approaches to improve the preparedness of US cities from an attack of biological warfare agents. The BWIRP's objectives are to assess the BW response problem, formulate an integrated approach to BW emergency response (including federal, state and local assets), and identify gaps and improvements in response capabilities. A companion Chemical Warfare IRP is focusing on enhancing responder protection, chemical agent detection and mass casualty decontamination.

1.2 BW Response Template

A multi-agency team comprised of over 60 experienced and working emergency responders and managers and technical experts from federal, state, and local agencies from around the nation was assembled to develop the BWIRP. There were

two primary products from the team's work in 1998: a BW Response Template and a prioritized list of response gaps and response improvement concepts.



The BWIRP team concluded that the overriding consequence of a large-scale unannounced BW attack will be the rapid emergence of large numbers of casualties. Response systems need to anticipate and be robust enough to deal with this probability. As much as possible, a response system should be able to detect and identify the medical problem at the earliest moment, administer appropriate medical prophylaxis to avoid disease in exposed victims, and then be able to keep up with the onset of casualties so that all are dealt with in a supportive and non-chaotic manner. If the attack involves high doses of a lethal disease, the ability to save many of the casualties exposed, even with immediate medical treatment, will be diminished. Therefore, the response systems should have the capability to deal with high numbers of fatalities. Casualties from an attack on a subway or building could be dispersed over wide metropolitan, multi-state, or multi-national areas. Conversely, an outside release against a residential area could result in severe incapacitation of entire housing complexes within one geographic location.

In short, a large-scale BW attack would result in a catastrophic medical emergency. Such an emergency would quickly saturate local emergency response and medical assets unless plans to cope with such an incident are in place beforehand. Such plans do not exist at this time for most cities. The problem then becomes: What would be an effective strategy for a city to cope with a BW attack, and how could that strategy be integrated across State and Federal levels?

The BWIRP team identified the need for and proceeded to formulate a generic BW Response Template that embodies the concepts and the specific activities that a city could perform to respond effectively to a BW incident. These are organized into groups referred to as components of the response template. Together, template components represent an integrated response system. The team developed timelines for each response activity in order to see how the activities could work together to deal with the dynamics of the onset of casualties for different attack scenarios. The team then analyzed the personnel and material resources needed to perform each response activity. Lastly, the team estimated the sources and timing of personnel resources from federal, state, and local assets in order to determine the overall practicality of the response template and to identify shortfalls. Throughout, the team took a "bottom up" approach and let the problem drive the solution.

The template could be used by any city as a starting point to formulate its local plans, protocols, and preparations to respond to a BW incident. The template offers the following advantages:

- It is a useful format through which to share the results of the in-depth analyses performed here with other cities to assist them in determining how they would respond to a BW attack.

- Commonality in response concepts and medical modules among all cities could be enhanced if they started their planning from a common response template. This commonality would facilitate the rapid and efficient augmentation of the city's assets with State, regional, and Federal assets when responding to a large-scale BW attack. It could also facilitate stronger mutual aid agreements among adjacent localities.

- The template appears to have application to any catastrophic medical emergency. Its adaptation by a city would significantly enhance the city's overall emergency preparedness.

Section

2

2 Background

This section describes the development of the BW Response Template and the NEHC concept.

2.1 BWIRP Workshops

The BWIRP team conducted a series of workshops in 1998 to examine the BW problem and to start to develop response solutions. Each workshop focused on a selected BW terrorist attack scenario, with varied BW agents and covert delivery means. The BW agents and predicted outcomes are shown in Table 1:

Table 1: BWIRP Scenarios

Scenario/Agent	Casualties	Fatalities
Francisella tularensis	1,100	380
Staphylococcus Enterotoxin B w/ Francisella tularensis	22,500	10,000
Bacillus anthracis	126,000	120,000
Venezuelan Equine Encephalitis	1,300,000	13,000
Rift Valley Fever	48,000	250

The examination of this range of BW attack scenarios and expected impacts helped identify a number of issues for consequence management, including:

- Rapid and large scale emergence of casualties
- Potential for high number of fatalities
- Geographic dispersion of casualties
- Likelihood of public hysteria
- Difficult to diagnose illness/agent
- Scene of attack not readily identifiable
- Residual hazard is agent dependent

2.2 BW Response Template Components

With these issues in mind, workshop participants examined and developed response activities designed to mitigate the emerging consequences of the scenarios. The product of this effort was a BW Response Template—a work breakdown structure of specific activities that a city could perform to respond effectively to a BW incident. The BW Response Template was designed to be flexible, consisting of multiple diverse components, and encompassing and combining such aspects as epidemiological surveillance, criminal investigations, and medical response.

The BW Response Template can serve as a useful point of departure for cities and communities in preparing their plans to respond to a BW terrorist attack. Major components of the generic BW Response Template are depicted in Figure 1. Five key operational decisions made by city officials will drive the response. These operational decisions divide the response template into three phases: continuous surveillance, active investigation, and emergency response. These phases may overlap and occur concurrently, as would other crisis and consequence management activities. The components, described in the 1998 BWIRP Final Report, are designed to work together as an integrated BW response system.

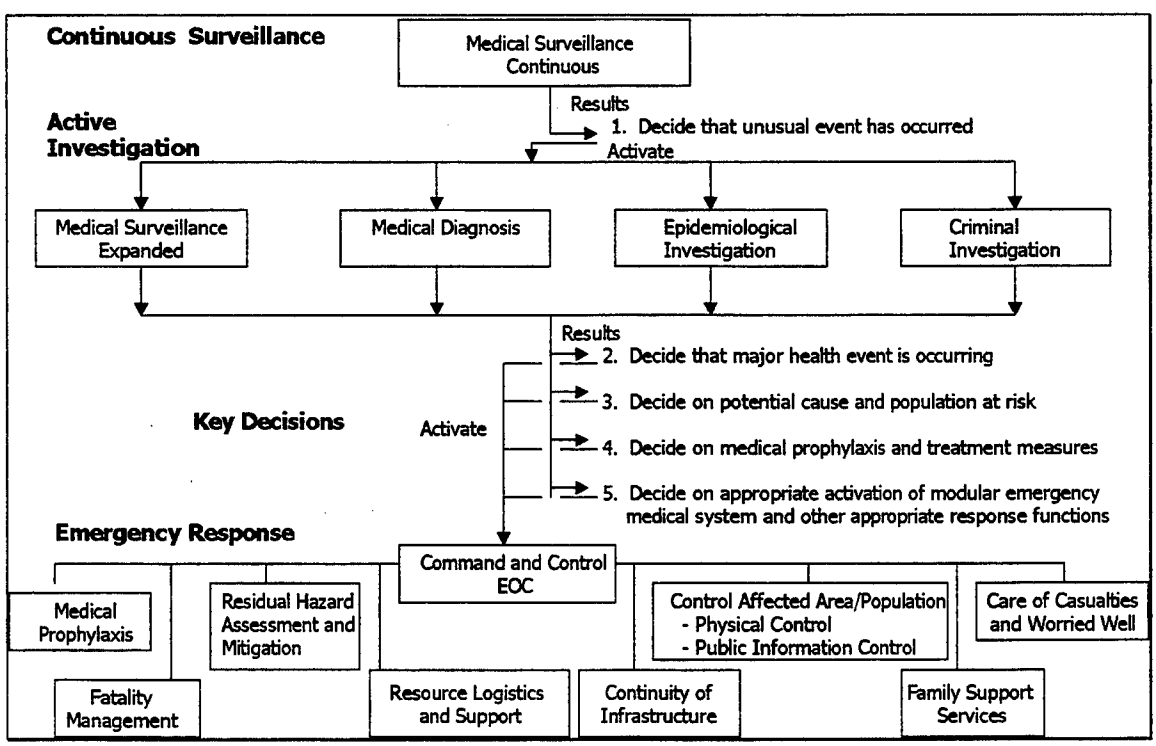


Figure 1: BW Response Template

2.3 Modular Emergency Medical System (MEMS)

As described previously, a BW agent terrorist attack is likely to produce a large number of casualties combined with possible public hysteria. The massive amount of casualties and worried well (persons who mistakenly believe that they may be infected) that are anticipated from a BW incident would likely overwhelm existing hospitals and medical facilities. The BW Response Template addresses this problem through the Modular Emergency Medical System (MEMS), which is designed to provide relief to the existing medical system by setting up a distinct organizational structure to efficiently process and coordinate the flow of patients. The MEMS concept is shown below in Figure 2.

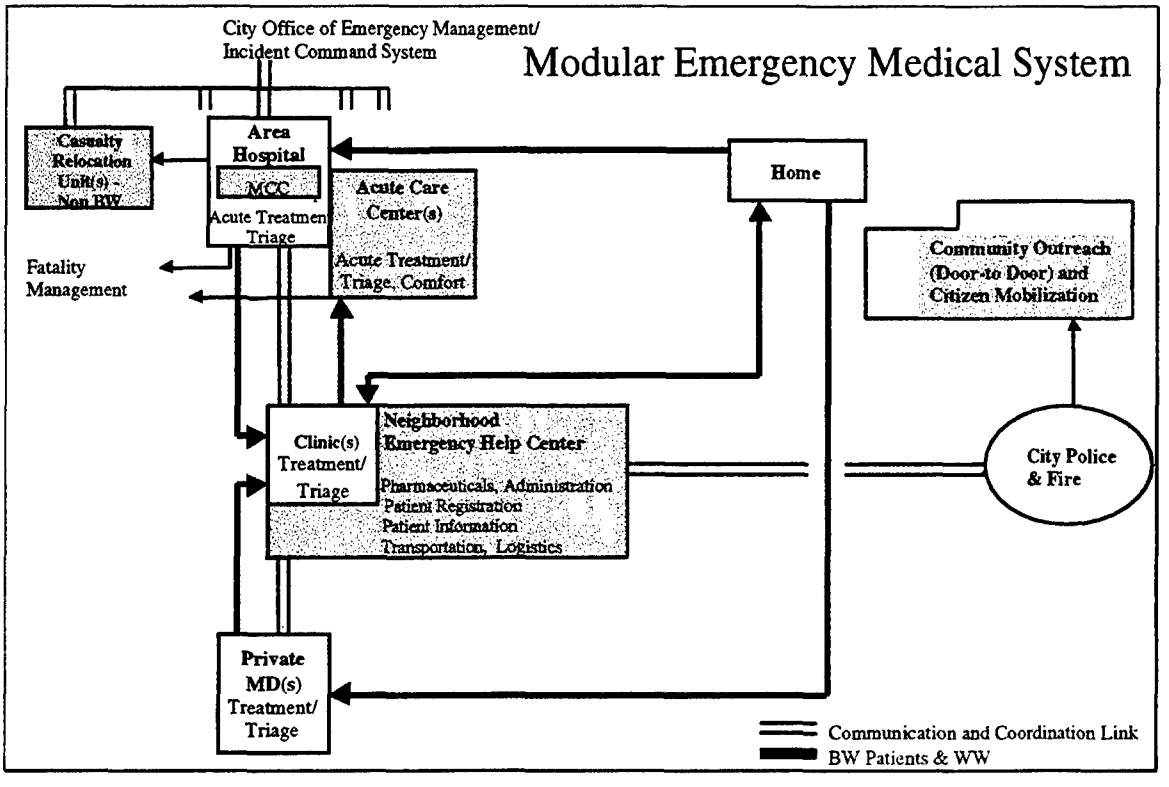


Figure 2: Modular Emergency Medical System

Management of this system is based on the Incident Command System/Incident Management System (ICS/IMS) that is currently used by the emergency response community. The MEMS is based on the rapid organization of two types of expandable casualty care modules which can be added to or removed from the system as needed—the Acute Care Center (ACC) and the NEHC. These modules are linked to an area hospital that oversees casualty care, medical logistics and information flow. Together, these two modules have the capacity to care for 4000

casualties (comprised of incident casualties, the worried well and the normal patient population).

The current medical system includes public and private area hospitals, clinics, ancillary care organizations and private physicians. These components can be integrated and expanded during emergency operations by activating pre-planned communication and coordination links between components and the application of additional resources as shown in Figure 2. Area hospitals will form their own internal emergency Medical Command Centers (MCC) to coordinate all sector health care operations. ACCs are established in buildings close to the area hospitals to help provide definitive and supportive care to acutely ill BW casualties. The division of responsibilities between the ACCs and the hospitals is currently being studied.

Existing clinics are expanded into NEHCs and provide the primary point of entry into the emergency medical system for BW casualties and worried well. Community outreach personnel and local volunteers will be used to assist the medical staff in these centers. Private medical doctors will send their BW casualties and worried well to these NEHCs. A sector outreach will be performed by police, firefighters, community health personnel and other officials to link home bound casualties to the NEHCs. If the ACCs and clinics become overwhelmed because of the extreme numbers of casualties, the police, community health personnel and other available officials, will distribute information, appropriate medication (after being triaged by trained medical personnel), and medical supplies to victims at their homes. They will also provide limited medical care by mobilizing a citizen home care effort.

Casualty Relocation Units will transfer non-BW hospital patients to remote locations in order to provide additional hospital space for BW casualties. During emergency operations, the area hospitals, clinics and private medical doctors will forego their autonomy and jurisdictional medical statutes and function as an integrated system. The individual area hospitals and their associated centers will be linked to the integrated Incident Command System to form a community-wide MEMS. In an alternate structure, ACCs and NEHCs could be established as stand-alone units not associated with area hospitals. Coordination of these Centers would then occur through the Community ICS.

The MEMS concept can be flexibly applied depending on the severity of the situation and the resources available within the affected community. The participating medical organizations will need to be pre-designated into community sectors. Locations for these facilities should also be pre-selected to assist the community to respond quickly and effectively to a BW or CW event, or other emergencies involving massive amounts of casualties. Furthermore, the community's MEMS would provide a framework into which state and federal resources could be quickly integrated to expand and sustain local emergency operations. The dynamics and logistics of establishing and sustaining this system and the application of federal, state, and local resources are still being assessed.

2.4 NEHC Functions

During emergency operations, a community's Office of Emergency Management (OEM) may activate the MEMS mass care strategy. Part of this plan calls upon pre-existing clinics and ancillary care organizations to expand their capabilities by mobilizing and integrating a community's available medical resources to become NEHCs. By augmenting these facilities with additional resources they can function as high-volume, community-based emergency health care centers. Depending on the community, these centers may or may not be affiliated with a hospital, and may or may not be physically attached to a hospital. The NEHC is designed, organized, equipped, and staffed specifically to provide basic medical services for those affected by an incident involving a BW agent.

The NEHC serves two primary purposes. The first is to function as a community triage point where casualties can quickly enter the medical system. This will help direct casualties away from emergency departments and allow hospitals to continue functioning. This will also help coordinate the massive victim tracking effort.

The second function of the NEHC is to provide initial evaluation and treatment, along with self-help information and instruction. Each NEHC is organized to process 1,000 casualties per 24-hour period. A staff of 82 physicians, nurses, administrators, prehospital care providers, medical clerical personnel and volunteers is required to operate this facility. In addition to providing a mechanism for the mass distribution of medications and basic treatment, the NEHC includes transfer agreements for movement of casualties to a hospital or ACC. The community OEM is responsible for ensuring that adequate medical transportation and logistical support is provided to each of the centers to initiate and sustain operations.

2.5 NEHC Structure and Process

The NEHC is organized into seven primary triage, treatment and administrative areas, and casualties are processed through the facility on a priority basis. Figure 3 shows the NEHC process flow.

2.5.1 Initial Triage Area

Initial Triage takes place as casualties enter the facility. An Emergency Medical Technician (EMT) assesses the casualties immediately upon their arrival to the center. The EMT employs a triage protocol that sorts casualties into four categories. The conditions for the four categories are described below.

- Immediate (RED tag) are those who need emergency life saving treatment. These casualties will have priority for treatment and transportation to the advanced care facilities.

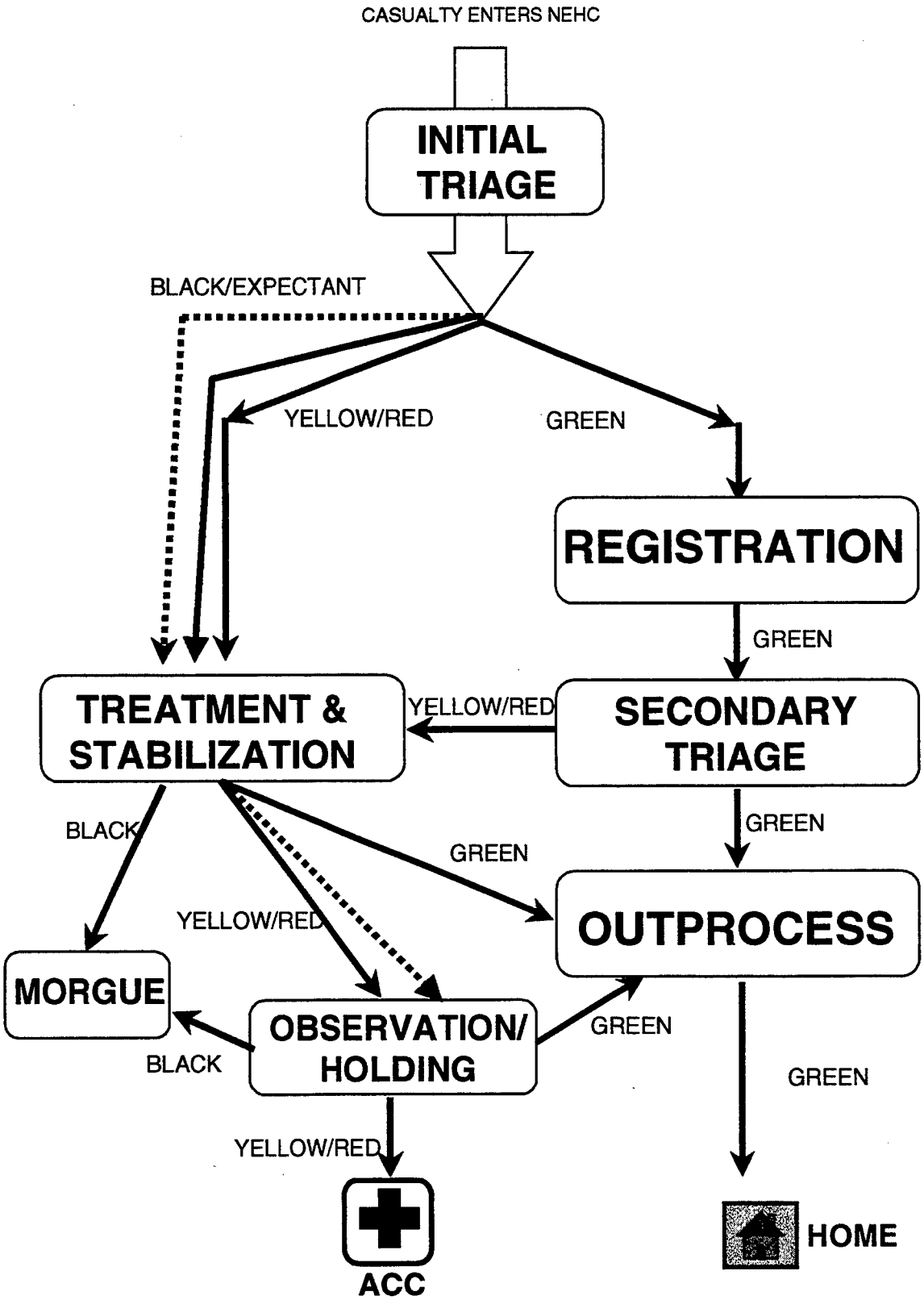


Figure 3: Neighborhood Emergency Help Center

- Delayed (YELLOW tag) are those who require limited medical intervention for stabilization and whose condition permits some delay in treatment.

- Minimal (GREEN tag) are those casualties who may or may not require treatment. They most likely will receive prepackaged pharmaceuticals, general self-help information, and be discharged or referred to their private physician.

- Expectant (BLACK tag) are those that arrive deceased or are expected to die prior to transport to an advanced care facility.

The EMTs begin by conducting a visual assessment on the casualty. After passing the visual assessment, all ambulatory casualties are categorized "Minimal/GREEN" and instructed to proceed to the NEHC Registration Area. All non-ambulatory or obviously acutely ill casualties are evaluated for respiration, perfusion, and mental status. These are known as the Simple Triage and Rapid Treatment (START) indicators. These casualties are assigned priorities of care: "Immediate/RED", "Delayed/YELLOW", or "Expectant/BLACK" and transported directly to the Treatment and Stabilization Area, bypassing registration.

2.5.2 Registration Area

Casualties who are well enough to be interviewed are registered by a team of clerks and volunteers. Each casualty is given a Patient Record Form that is used to record information and treatment in each area of the NEHC.

2.5.3 Secondary Triage Area

Following registration, casualties are reassessed and possibly recategorized at the Secondary Triage Area. They are assessed for five vital signs (temperature, respiratory rate, blood pressure, pulse rate and blood oxygen) and five critical assessment markers (alertness, photophobia, stiff neck, breathing, and chest pain).

2.5.4 Out-Processing Area

Casualties not requiring care beyond prophylaxis and self-help information are directed to the Out-processing Area. Casualties sent to the Out-processing Area are given an instructional briefing, issued prophylaxis, and discharged. Discharge will include collection of casualty records and referral to psychological counseling or other human relief services.

2.5.5 Treatment and Stabilization Area

Acutely ill casualties or those identified as needing additional medical care during Secondary Triage are categorized "immediate" or "delayed," and forwarded to the Treatment and Stabilization Area. Casualties are treated according to an established protocol that includes Advanced Cardiac Life Support (ACLS), Advanced Trauma Life Support (ATLS), burn management, and Pediatric Advanced Life Support (PALS) care.

2.5.6 Observation/Holding Area

Following initial stabilization and treatment, casualties are transferred to the Observation/ Holding Area. Casualties considered unsalvageable/expectant are forwarded to the Observation/ Holding Area and monitored, until all casualties assigned "immediate" priority have received care. All other casualties transferred to the Observation/ Holding Area will continue treatment while under medical supervision. Casualties requiring in-patient care are transferred to hospitals or ACCs once they have been stabilized within the limitations of the NEHC capabilities. In some instances, casualties moved from the NEHC may not be clinically stable due to severity of their condition, limited medical resources and time constraints. Casualties whose condition allows may be released from the Observation/Holding Area for out-processing.

2.5.7 Temporary Morgue

Deceased casualties are pronounced dead by a Stabilization Team Physician and forwarded to the center's Temporary Morgue.

2.6 NEHC Staffing

An enormous amount of casualties seeking treatment will cause hospitals to recall a large portion of a community's emergency medical personnel. This will cause a shortage in available skilled providers. Such an event may leave few qualified emergency medical personnel to staff the NEHC. For example, the types of physicians that will likely staff the NEHC will be family practitioners, dentists, dermatologists, and/or gynecologists. These physicians may not have used their emergency medicine skills in many years and some may never have seen the inside of an Emergency Department. They may not be current in treatment regimes or have the ability to administer intravenous lines, "run" a cardiac arrest, or even recognize symptomology of a life threatening illness.

Therefore, a team approach is used whenever possible to allow the staff to assist each other. There are six types of staff who will interact with casualties.

2.6.1 Physicians

Physicians are responsible for the medical care provided in the NEHC. This includes the medical evaluation, diagnosis, and assigning treatment and disposition of the casualty, as well as the direction and coordination of all other care provided to the casualty. Physician Assistants/Family Nurse Practitioners may also fill this role.

2.6.2 Nurses

Nurses are responsible for the nursing care of casualties, including assessment planning and evaluation of response to medical interventions. They must possess appropriate credentials. They must be able to provide evidence of patient care experience. They must possess and show evidence of the knowledge and skills

necessary to deliver respective levels of care. Physician Extenders may also fill this role.

2.6.3 Paramedics

Paramedics provide skills that are similar to nurses, but they may have less experience. Paramedics must also possess appropriate credentials.

2.6.4 Emergency Medical Technicians (EMT)

These technicians are responsible for triage and providing assistance to the nursing staff in the care and treatment of casualties in the NEHC. They must possess current certificates and/or licenses to practice. They must have experience in the medical field using their certificate/license. This category also includes nurses assistants.

2.6.5 Medical Clerical Personnel

The clerks in the NEHC are responsible for generating the paperwork necessary to run an NEHC. They are the facilitators who coordinate moving casualties through the NEHC. They are responsible for answering phones and ensuring that all communications are carried out throughout all the stations and other modules in the MEMS. They are required to have some experience in medical responsibilities and understand medical terminology. Lastly, they are responsible for supervising the volunteers in their sections.

2.6.6 Volunteers

Volunteers will assist in performing registration, internal transportation, and outprocessing. They also assist the medical staff in recording casualty information in the secondary triage and treatment areas.

Section
3

3 Validation Approach

One of the objectives of the BWIRP is to demonstrate that the BW Response Template performs as intended, or is "valid." To determine how well the template works, the program began a test and evaluation phase in 1999. The NEHC is the first template component to be assessed. The remainder of this report describes how the NEHC concept was validated.

Validation testing is a new approach in a disaster medicine community that is used to conducting readiness exercises. In a readiness exercise, the purpose is to find out how well test participants follow certain procedures or react to events. However, in these template validation tests, the purpose is to find out, "will the template perform as expected?"

The NEHC validation approach is based on operations research methodologies, and involved four major steps:

- Step 1: Working group develop and verify performance expectations.
- Step 2: Measure actual performance during two test exercises.
- Step 3: Compare actual to expected performance.
- Step 4: Assess results and recommend improvements.

These steps are linked together as shown in Figure 4 and described below.

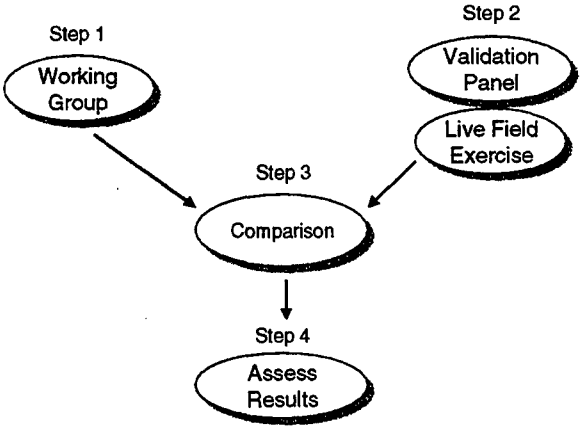


Figure 4: NEHC Validation Approach

Step 1 involved helping the BWIRP team and an NEHC Working Group to develop and verify measures of effectiveness, a primary scenario, a process flowchart, probability trees and a simulation model of the NEHC concept. These tools allowed the Working Group to state specific performance expectations of the concept.

In Step 2, two evaluation protocols were used to gather data and measure actual performance. Actual performance data were gathered though a live field exercise, in which a facility was set up with trained staff. Actors portraying casualties with various symptomologies were processed through the facility in a scaled-down time sequence, and various performance data were captured and analyzed.

The live exercise was supplemented by a desktop exercise with a validation panel of independent emergency medicine and epidemiology experts. The desktop exercise was used to validate triage and treatment aspects of the NEHC that could not be tested in the live exercise.

In order to compare actual performance to expected performance, Step 3 makes use of a multi-attribute utility model that was built using Measures of Effectiveness (MOE) as criteria and the expected performance and actual performance data sets as alternatives.

Step 4, results and recommendations, are provided at the end of this report.

3.1 Measures of Effectiveness (MOE)

MOEs were identified early in the validation process. A complete set of MOEs would measure quantity and quality aspects, and internal and external performance, as shown in Table 2.

Table 2: Categories of MOEs

	Internal	External
Quantity	Capability to process presenting casualties	System capability to process the population-at - risk
Quality	Impact on presenting casualties	System impact on the population-at-risk

The scope of the first year testing, however, was limited to "internal" performance only. Internal "quantity" MOE's were defined as the capability of the NEHC structure, procedures, and resources to process presenting casualties. For this analysis, three specific measures were identified: facility throughput, casualty cycle time, and staff utilization. The quantity MOE's were assessed during the live field exercise.

Internal "quality" MOE's measure the resulting impacts of medical care received on the casualties actually processed through the NEHC.

For this analysis, three specific measures were identified: treatment efficacy, triage disposition and casualty data completeness. The first two quality MOE's were assessed during the validation panel exercise and the last was to be assessed during the live field exercise. The following are definitions of the six MOEs used in the NEHC validation process.

3.1.1 Facility Throughput

The number of casualties processed through the NEHC to be sent to the ACC or returned home in a 24-hour period. The BWIRP team established a design goal of 1,000 casualties per day.

3.1.2 Casualty Cycle Time

The amounts of time casualties spend processing through the NEHC to be sent to the ACC or returned home. Overall cycle time is composed of the time transiting from one area to the next, the time waiting to be serviced by a staff member, and the time spent being serviced by a staff member.

3.1.3 Staff Utilization

The percent of time the facility staff is providing direct or indirect casualty services. The utilization is measured for each of the six types of staff. Direct care is the time actually servicing casualties. Indirect care involves administrative tasks. Any time not performing direct or indirect tasks is considered idle time.

3.1.4 Treatment Efficacy

The percent reduction of deaths due to casualty processing through the NEHC (mortality) and the percent reduction in effects or duration of illness due to casualty processing through the NEHC (morbidity).

3.1.5 Triage Disposition

The percentage of BW agent-infected casualties sent to the ACC and the percentage of non-infected casualties sent home. The initial and secondary triage protocols determine the disposition of casualties. Since the NEHC staff only assesses casualty symptoms, they have no way of knowing who is really infected and who is not. More "conservative" triage protocols tend to send a greater percentage of casualties to the ACC, lowering the risk to the population of infected casualties. At the same time, more conservative protocols tend to send more non-infected casualties to the ACC, wasting limited transportation, bed space and medical staff. Triage protocols must strike the proper balance between risk reduction for those people actually infected and the efficient use of scarce resources.

3.1.6 Casualty Data Completeness

The ratio of completed information items on the Patient Form to the items required to be collected.

3.2 Process Flowchart

After the MOEs were established, a flowchart of the processing steps intended for each casualty was developed. The Process Flowchart helped define the key activities and events in the NEHC design. A flowcharting tool called *Inspiration* was used with the Working Group experts to lay out the process flow of presenting casualties, and to help elicit and capture the specific process steps involved and detailed descriptions in a single model. The resulting flowchart is shown in Figures 5 and 6.

The process flowchart was very helpful to the Working Group in thinking through the specific areas, functions, and casualty paths that were merely implied in the template. When the group first met, there was no common understanding of what was going to happen inside the facility. The template only provided a work breakdown structure (WBS) format placed on a timeline that was not useful for designing the internal workings of the component. The process flowchart allowed the Working Group to focus on key design issues, such as numbers of triage stages and how best to register casualties.

The Working Group developed the flowchart in a collaborative effort in real time. The group made notes in the *Inspiration* software as they discussed each block, saving time and providing documentation. The members identified areas that they wanted to test and those that would not be tested. They also began to get an appreciation for the implications of the triage and treatment protocols that they would develop later. Finally, through the flowchart they were able to see the multiple paths the casualties would take through the facility and the dispositions of the casualties.

A particular concern in the design was that presenting casualties might leave the facility before completing the registration process if they had to wait to be seen. This behavior, known as reneging, was assumed to be a potential problem at registration and secondary triage. Once a casualty was told that he or she needed treatment, it was assumed that the casualty would not renege.

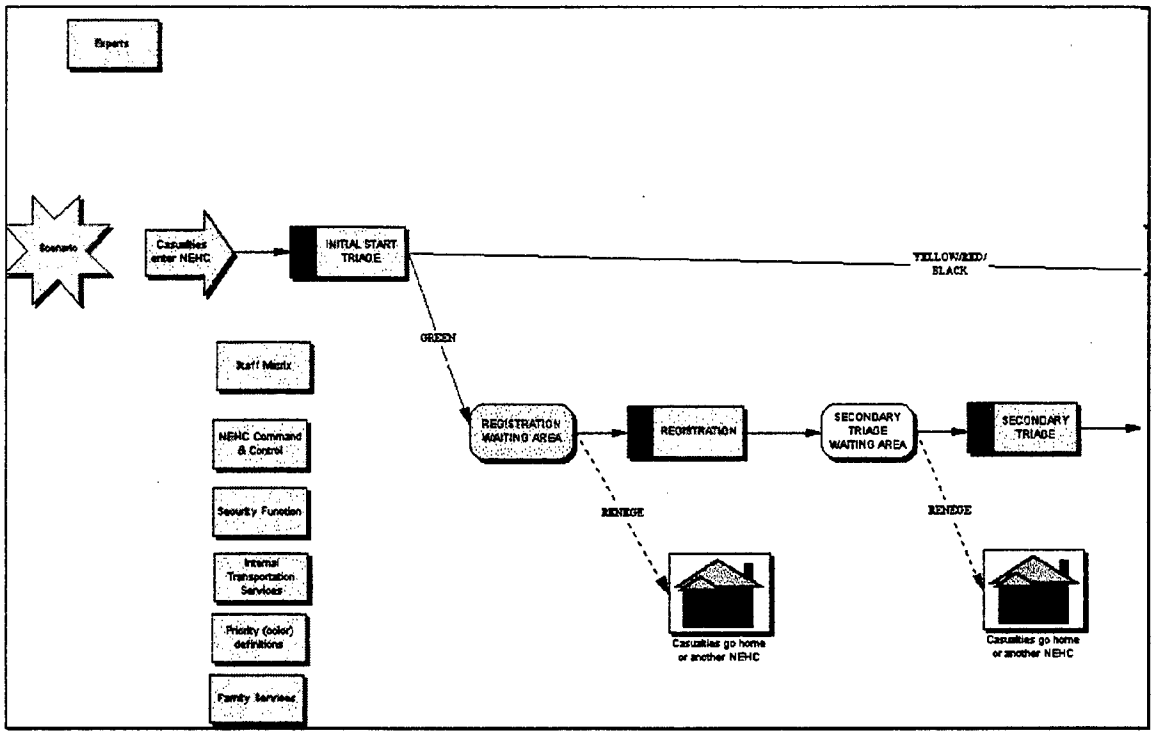


Figure 5: NEHC Process Flowchart (Part 1)

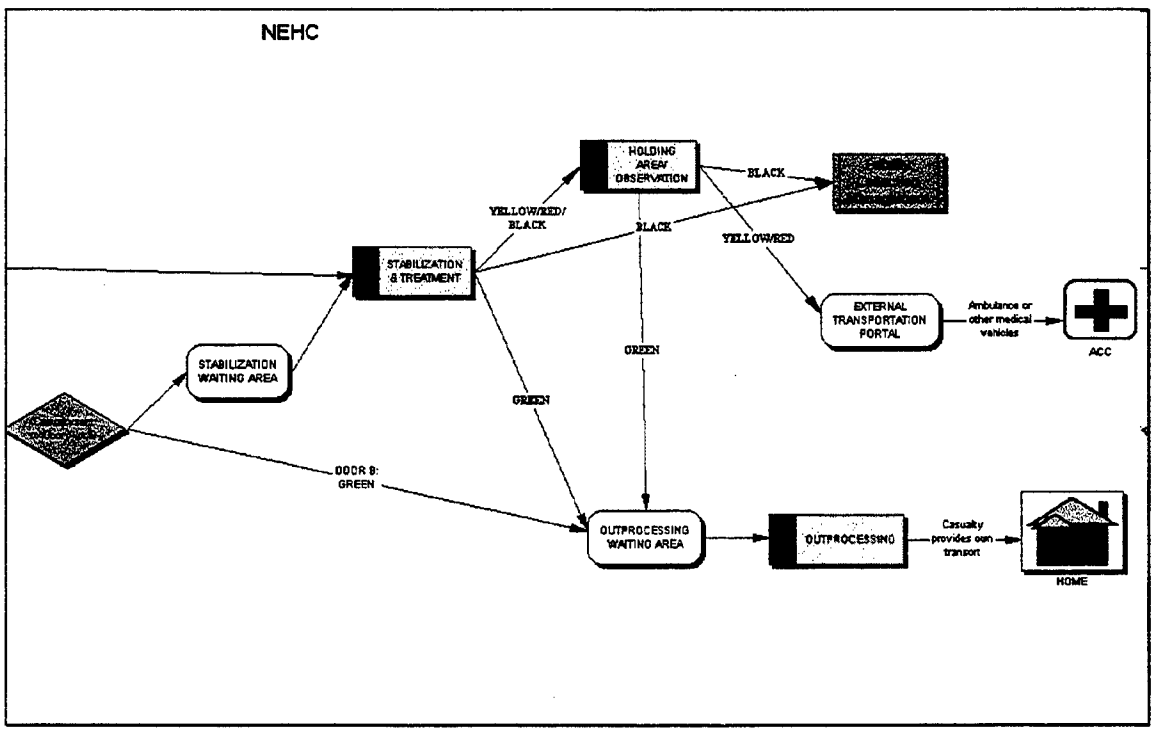


Figure 6: NEHC Process Flowchart (Part 2)

3.3 Simulation Model

Next, the casualty flow process was converted into a dynamic simulation model. A desktop simulation program called *Extend* was used to build a representation of the structure and processes of the NEHC. *Extend* allows discrete event modeling, which represents items within a system, such as people, as individual objects possessing attributes. The NEHC simulation was built as a discrete event model, with each casualty represented as an item, and staff time represented as resource pools.

The model shows how different types of casualties move from area to area, the time it takes to process a casualty at each area, the staff time needed, and the expected dispositions of the casualties. The simulation output plots provide a view over time of the number of casualties processed through the NEHC facility and their dispositions, as well as staff utilization and the times to complete each activity. These are the expected values for the "quantity" MOEs discussed above. Figure 7 shows a portion of the simulation model.

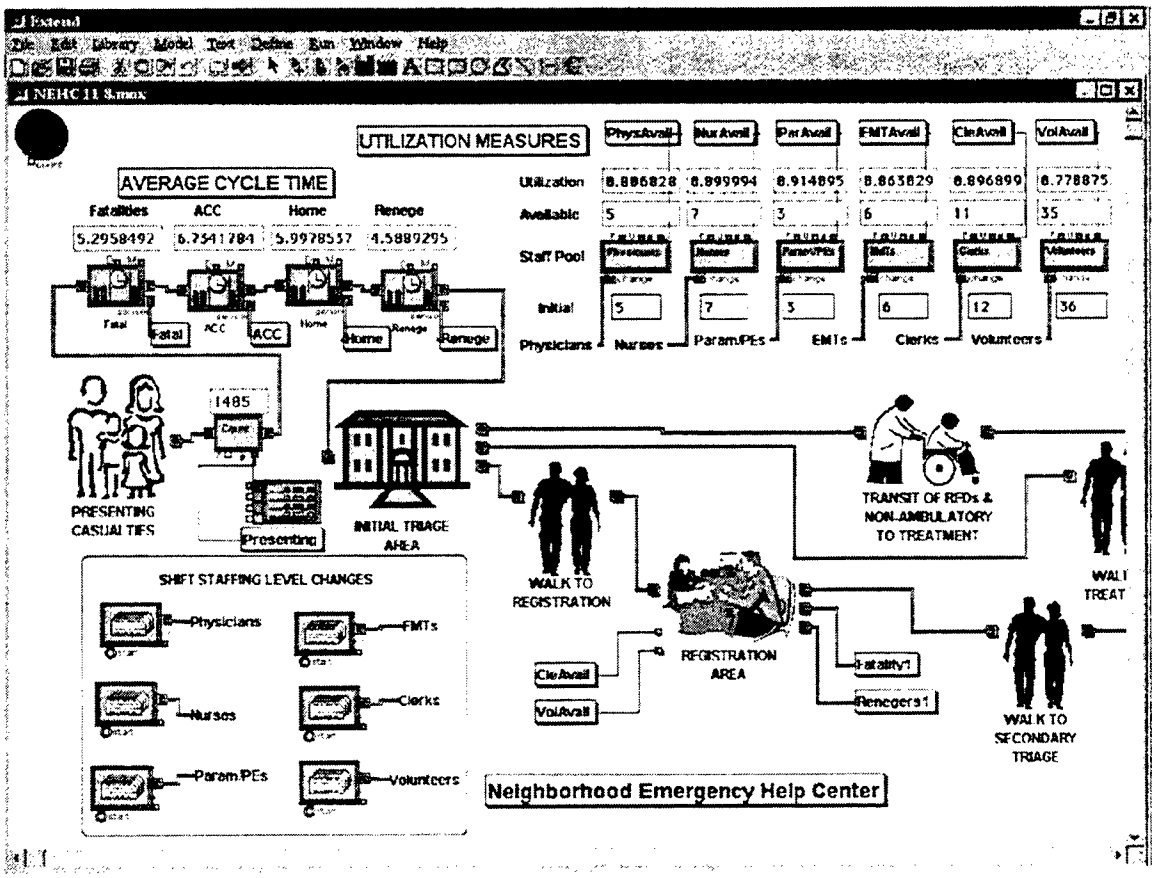


Figure 7: NEHC Simulation Model

The finished model also helped the Working Group examine the impacts of changing some of the design variables. For example, the secondary triage rules have a direct impact on the percent of casualties who will be sent to the ACC. The Working Group could vary the triage procedures, for instance, by requiring fewer positive symptoms before directing casualties to the ACC, and see the increase in the percent of casualties expected to be sent there. Similarly, the Working Group could vary staff levels and see the impact on casualty flow.

The process of building the simulation model proved as useful as the finished product. The questions raised by the modelers in their effort to accurately represent the concept helped the Working Group to refine the design. For example, additional paths were added for casualties who recovered sufficiently in the treatment and holding areas to be able to return home with medications.

The NEHC simulation model, and simulations of other components, have multiple uses for the BWIRP. First, they can help subject matter experts gain insights into the proposed component design. They can help suggest the appropriate measures and ways to collect the data during testing. They can be used to provide inputs to workshops and tabletop exercises. They can be used to test component performance in other situations which there may not be time or funds to conduct a live field test. Finally, they can be used to show cities and communities how the template concepts can be tailored to their unique circumstances.

3.4 Probability Trees

While most of the MOEs associated with the NEHC validation could be modeled in the Extend simulation (such as facility throughput, casualty cycle time, staff utilization, and triage disposition), it was found that the simulation was not well suited to analyze the treatment efficacy MOE.

Treatment efficacy measures the reduction in mortality and morbidity due to the NEHC. Mortality is the rate of death resulting from the incident. Morbidity is the duration and severity of illness resulting from the incident. Since these measures are estimated as probabilities, they were best modeled using a probability tree. Probability trees combine the probabilities of a casualty's state of infection and presenting condition with the probabilities that a casualty will improve or recover. A decision analysis package called *DPL* was used to build these trees. Figure 8 shows a probability tree for reduction in mortality.

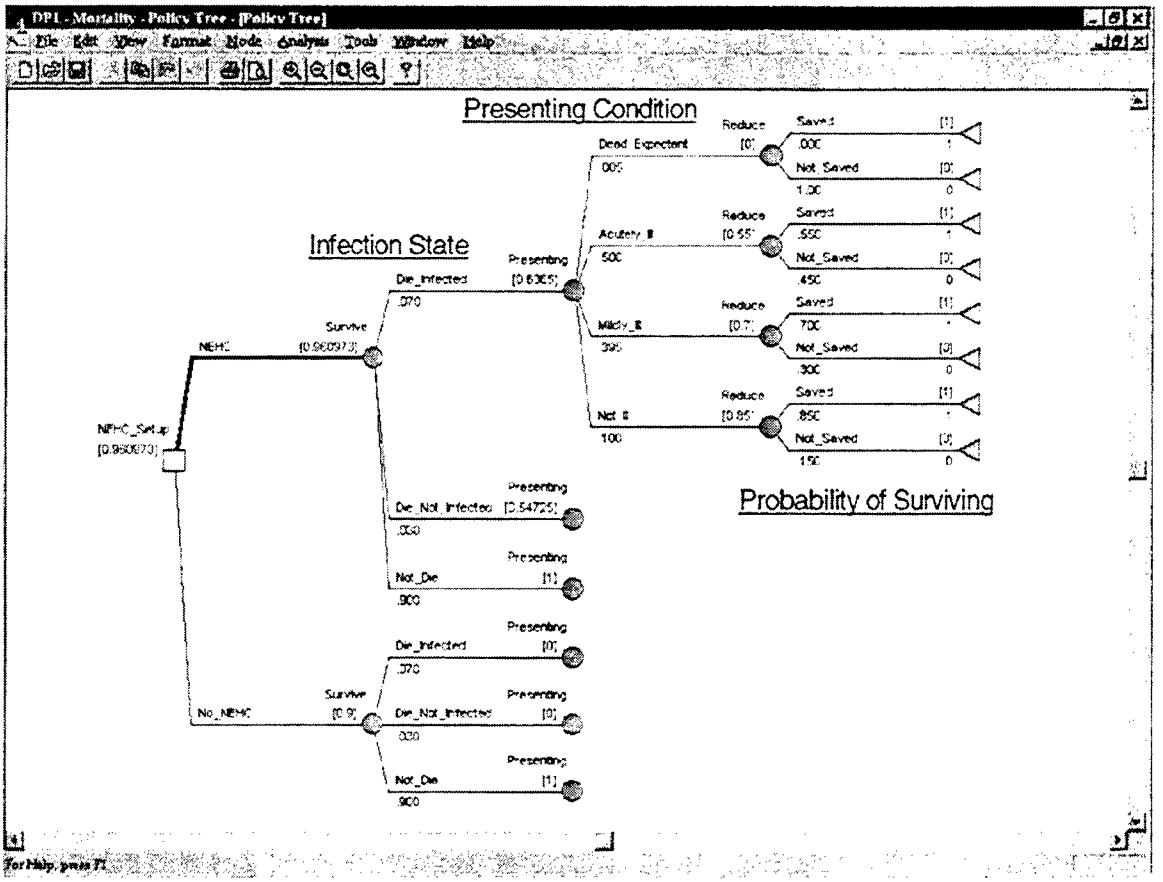


Figure 8: Estimated Reduction in Mortality

In this probability tree, the yellow square represents the "decision" to set up an NEHC or not. The top branch coming out of the yellow box shows the path of probabilities if we assume the NEHC is set up. The bottom branch coming out of the yellow box shows the path of probabilities if we assume the NEHC is not set up. On the top branch next to the first green circle, we see the total probability that a presenting casualty will survive, given the NEHC is set up (0.960973). On the bottom branch next to the first green circle, we see the total probability that a presenting casualty will survive, given the NEHC is not set up (0.9).

These total probabilities are the accumulated products of infection state (will die-infected, will die-not infected, and will not die), presenting condition (dead/expectant, acutely ill, mildly ill, and not ill) and probability of surviving (saved, not saved) along each path of the probability tree. The blue triangles show that a "saved" casualty scores a 1 and a "not saved" casualty scores a 0. The detailed branches of the tree are only shown in this example for the top "will die-infected" green node, but each of the other "infection state" green nodes have a similar set of detailed branches (the likelihood of reduction probabilities will differ).

3.5 Multiple Criteria Decision Model

In the final step, the MOE's were combined to create a single overall measure of validity. Multi-attribute utility (MAU) analysis was used to structure the MOE's in the form of a hierarchy. Figure 9 shows the MAU model structure built using *Logical Decisions for Windows (LDW).* Each of the three quantity and three quality MOEs was decomposed into its sub-MOEs, if required. For example, staff utilization was broken down with a node for each of the six types of staff.

MAU, based on traditional utility theory, is one of the primary decision analysis approaches to multiple criteria decision making (MCDM). The method scores alternatives against a set of criteria and then weights the criteria according to their importance in making the decision. For each alternative, the scores are multiplied by the criteria weights and then added together.

The Working Group developed weights and scoring scales for the criteria. The expected performance of the NEHC in the primary scenario was established as the top of each performance scale and assigned 100 points. This allowed the model to represent the expected performance with an overall score of 100. The bottom of each scale was set at a level, below which was deemed unacceptable and, thus, assigned 0 points. The results of the validation exercises were entered into the model upon completion of the testing.

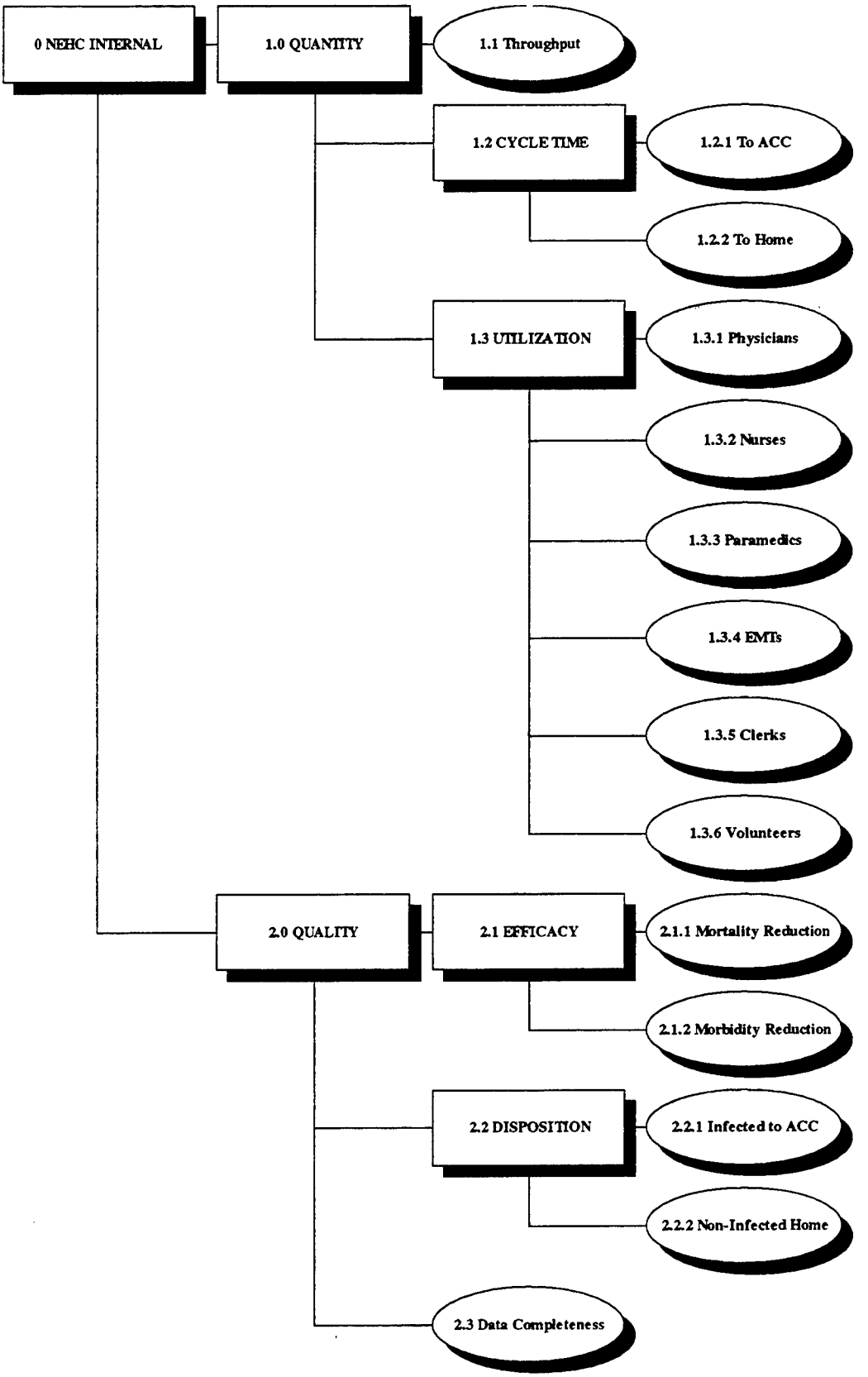


Figure 9: Multiple Criteria Decision Model

The Working Group then developed relative weights for each MOE. Using LDW, pairwise comparisons between each criterion were made and allowed the Working Group to reach consensus on the relative importance of the various MOEs.

Since template component validity is a relative concept, the overall evaluation goal was to come as close to the expected or desired results as possible. In the notional example shown in Figure 10, the results of the exercise using the primary scenario and the first two alternative scenarios are quite acceptable, while the results of the last scenario indicate that there would be a problem applying the NEHC template component in this situation. Either the NEHC design must be modified to better accommodate this last scenario, or a policy established which calls for a different approach should this situation arise.

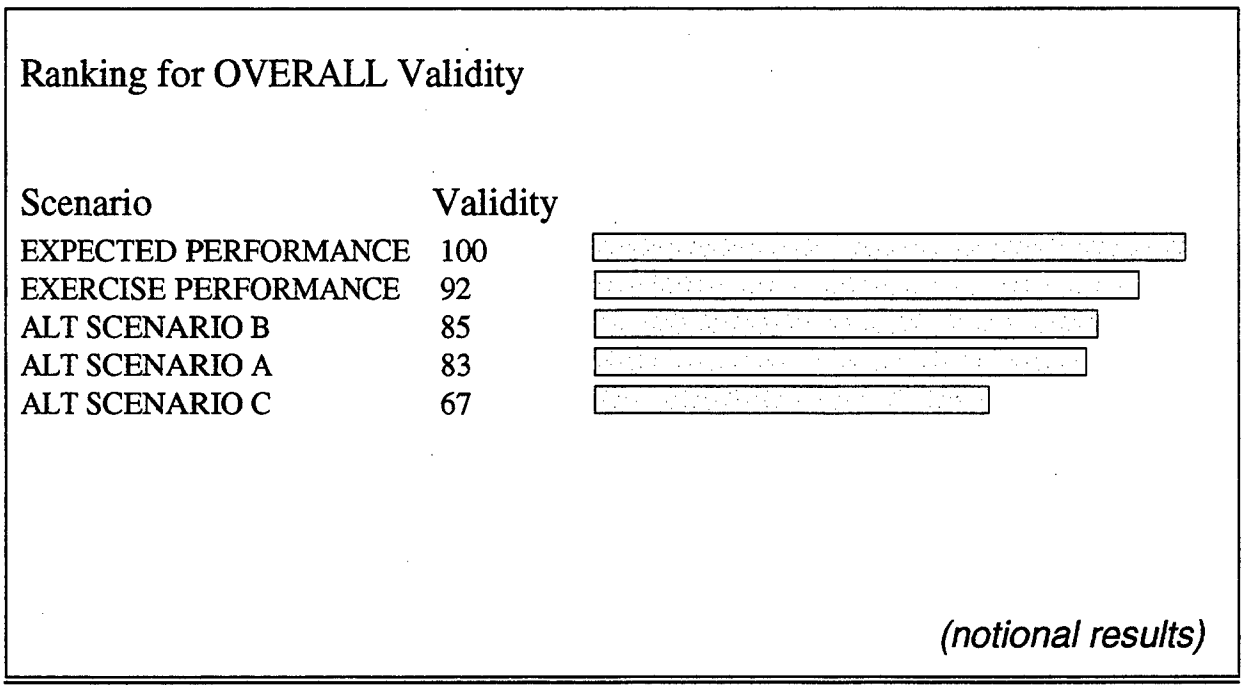


Figure 10: Overall NEHC Performance

In addition to evaluating the overall validity of the proposed component design, the MAU model facilitates trade-off analysis among design parameters. For instance, the NEHC design may be improved by adding several more staff, possibly reducing the score on a low weighted MOE such as staff utilization and improving the score on a high weighted MOE such as cycle time.

Finally, the MAU model, in conjunction with the process flowchart, the simulation model and the probability trees, can be used to help validate modified or customized NEHC designs that each city may desire to implement.

The next section describes the assessments that the Working Group made to understand the implications of their concept for the NEHC.

Section

4

4 Verification of NEHC Design

Once the BWIRP team workshops completed the initial conceptual design, an NEHC Working Group of subject matter experts was formed to develop the detailed design of the NEHC's structure and operational procedures, including the triage and treatment protocols, and the scenario to be used for the validation tests. The Working Group membership is shown in Table 3.

Table 3: NEHC Working Group

Name	Organization
Dr. Dario Gonzalez	New York City
Ms. Annette Sobel	SNL/HQ NMANG
Mr. Jim Sowder	Fort Worth Fire Department
MAJ JC Linn	JRMPO
Dr. Rick Spiegel	Centers for Disease Control
Mr. Kevin Kraus	New York State Emergency Mgmt Office

(Note: Not all members were present at all meetings.)

The Working Group met three times during 1999: February 10-11, June 25, and July 29. Table 4 shows the detailed design elements developed by the Working Group, the related MOEs, model types and the exercise used to test the area.

Table 4: Working Group Detailed Design

Design Elements	Related MOEs	Model	Test Exercise
Primary scenario	All	Simulation & probability trees	Both
Staffing levels	Facility Throughput Staff Utilization	Simulation	Live Field Exercise
Processing times	Casualty Cycle Time	Simulation	Live Field Exercise
Triage protocols	Data Completeness Triage Disposition	Simulation	Live Field Exercise Validation Panel
Treatment protocols	Treatment Efficacy	Probability trees	Validation Panel
Mortality and morbidity reduction	Treatment Efficacy	Probability trees	Validation Panel
MOE weights	All	Multiple criteria model	N/A

As the Working Group members debated the detailed NEHC design at each meeting, they made significant modifications and refinements to the facility structure and patient flow. The following sub-sections describe the NEHC design resulting from the final Working Group meeting.

4.1 Staffing Levels

The Working Group created an NEHC design that calls for a total staff of 82 personnel per shift (two 12-hour shifts). Of that total, 13 are involved in administration, management, security and housekeeping. These functions do not service casualties and were not considered testable. Another 8 staff are involved in external transportation, supply, operations, and the temporary morgue. The program did not test these positions because of resource constraints. Of the remaining 61 positions, there are two ways that staff could be assigned: fixed and flexible. Fixed staff must remain at their position, even if no casualties are being processed at the time. Flexible staff could be shifted within the facility depending on the work flow. The table below shows the staffing levels for each area and staff type.

Table 5: NEHC Staffing

	Initial Triage - Flexible	Registration - Fixed	Registration- Flexible	2nd Triage - Fixed	2nd Triage - Flexible	Treatment - Fixed	Treatment - Flexible	Observation - Fixed	Observation - Flexible	Outprocessing - Fixed	Outprocessing - Flexible	Internal Trans - Fixed	Internal Trans - Flexible	Total
Physicians							3	1		1				5
Nurses							3		3	1				7
Paramedics							3							3
EMTs	1				5									6
Clerks			2	1		1		1		1	1	1		8
Volunteers		1	6	1	5	2	3		3	3	2		6	32
Total	1	1	8	2	10	3	12	2	6	6	3	1	6	61

4.2 Processing Times

Processing times are the range of time expected to provide service for each casualty at each NEHC area. The Working Group first estimated processing times for each area while developing the process flowchart. The times were then refined as each

protocol was developed. The final expected ranges are shown in Table 6. The distribution within each range was assumed to be uniform.

Table 6: Estimated Processing Times

Station	Time (min)
Initial Triage	½ to 1
Registration	3-5
Secondary Triage	5-8
Treatment & Stabilization	15-45
Observation/Holding	45-60
Outprocessing – briefing	10-15
Outprocessing – discharge	3-4

4.3 Primary Scenario

The primary scenario consisted of a description of the BW agent incident, the expected casualty presentation rate, expected casualty infection states, and expected casualty presenting conditions.

The Working Group first developed a specific BW agent incident for the validation test. The agent in the scenario is Tularemia, in aerosol form, used in a subway attack. The attack occurs during flu season and affects a normal cross-section of the population, to include elderly and children. Identification of the agent has occurred, and the NEHC is set up on Day 4 after the attack, which represents the highest percentage of infected casualties versus worried well (non-infected) casualties.

The BW response template called for an NEHC facility that can process 1,000 casualties in a 24 hour period, which equates to an average *casualty throughput* of 42 casualties per hour. The template, however, did not specify what pattern of casualties were assumed. Based on the BW agent incident and output from a casualty generation model, the Working Group estimated the casualty mix that would present to the NEHC in terms of casualty presentation rate, casualty infection states, and casualty presenting conditions.

The following probability estimates for the presenting casualty mix and for the impact of the triage and treatment protocols provide the detail needed to establish the expectations of the Working Group as it developed the NEHC concept. These expectations were then "tested" using independent estimates and the live field exercise in order to validate the NEHC concept.

4.3.1 Casualty Presentation Rate

The expected distribution of casualties over a 24 hour period is critical to the design. If casualties are expected to arrive at a steady rate, the staffing can be smaller or wait times shorter than if casualties arrive in clusters. The Working Group developed three potential casualty presentation rates.

The first rate (Figure 11) was a steady state over the course of a 24-hour day. This was assumed to have an exponential (Poisson) casualty arrival distribution within each hour. The plot begins at midnight and each vertical bar represents six minutes.

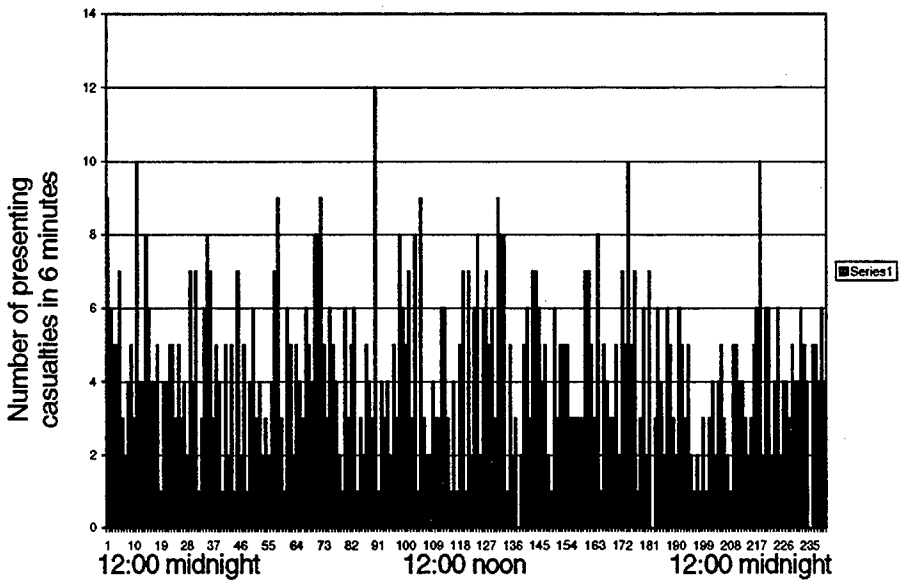


Figure 11: Steady State Daily Casualty Arrival Rate

The second presentation rate (Figure 12) assumed that most casualties would tend to arrive during the early morning period and the early evening period, corresponding to before and after the normal workday. This distribution was based on a study of presenting flu cases conducted by the Centers for Disease Control. Again, a Poisson arrival rate was used within each hour.

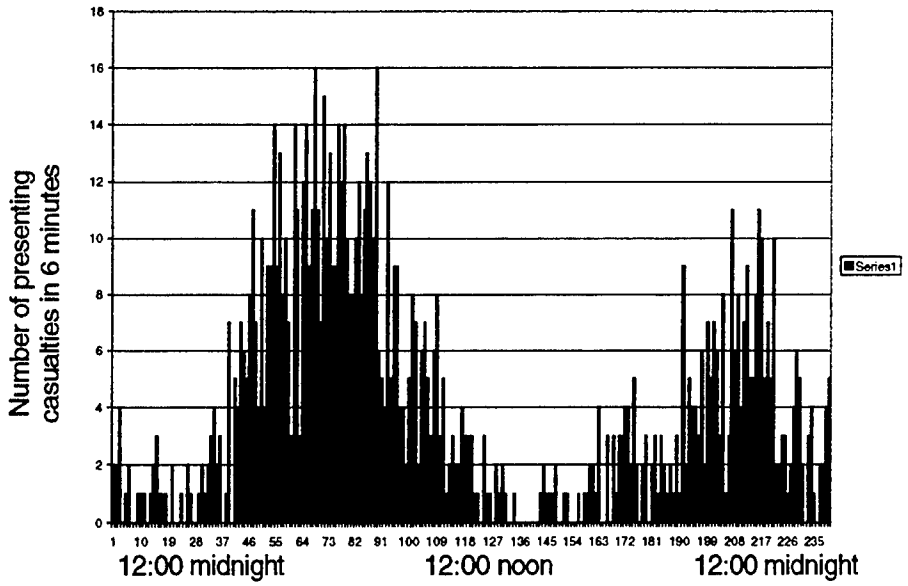


Figure 12: Two-Peak Daily Casualty Arrival Rate

The third rate (Figure 13) assumed a single period during the day when most casualties would tend to decide to go to the NEHC. That period was in the late afternoon and evening. This distribution was based on the BWIRP Casualty Generation Model. A Poisson arrival rate was used within each hour.

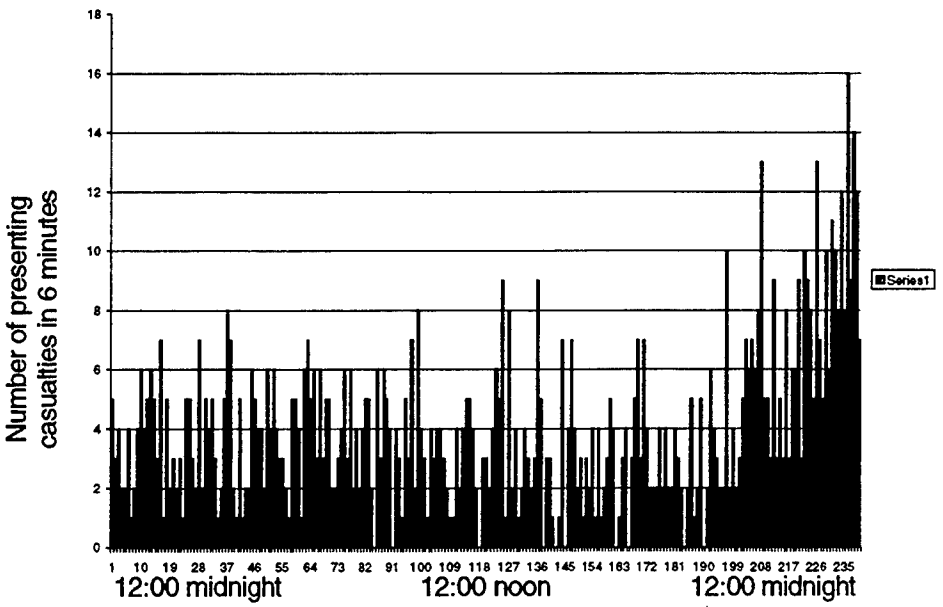


Figure 13: One-Peak Daily Casualty Arrival Rate

The importance of this analysis is that the three distributions would each result in a different challenge for staffing the NEHC. The steady state distribution facilitates

efficient staffing and equal day/night shifts. The two-peak distribution would require a larger staff to handle the peak demand periods and substantial "down time" in between. The one-peak distribution could be handled efficiently with a smaller dayshift and a larger night shift.

While a logical case can be made for the one or two peak distributions, the Working Group decided to use the steady state casualty arrival distribution for the validation testing because there was no empirical evidence to support any one distribution. The consequence of this assumption is that the NEHC design was tested using the least demanding casualty arrival distribution.

4.3.2 States of Infection

State of infection describes the percentage of NEHC arrivals who will be infected, and their likely outcome. The Working Group estimated the percentage of casualty arrivals who will be infected on Day 4 following a BW incident (Table 7). The estimate was based on the BWIRP Casualty Generation Model. The Working Group selected Day 4 because it felt that Day 4 represents the most demanding casualty mix that the NEHC would face in this scenario (67% infected, 33% not infected). Those not infected include worried well and those with injuries or other illnesses. *Sequela* is a lingering, chronic condition that may result from exposure to some BW agents. While not an outcome of tularemia exposure, a sequela condition may apply in other scenarios.

Table 7: States of Infection

State of Infection	Percent
Not Infected	33
Infected, would die without treatment	7
Infected, would have sequela without treatment	0
Infected, would fully recover without treatment	60

4.3.3 Presenting Conditions

Presenting condition describes the percentage of casualty arrivals who, given a particular state of infection, are dead on arrival, feeling acutely ill, feeling moderately ill, or not feeling ill. The Working Group estimated percentages for Day 4 of the scenario. These percentages are shown in Table 8.

Table 8: Presenting Conditions

	Presenting Condition (percent)			
Given State of Infection:	**DOA**	**Feeling Acutely Ill**	**Feeling Moderately Ill**	**Not Feeling Ill**
Not Infected	0.5	1.5	11.5	86.5
Infected, would die without treatment	0.5	50	39.5	10
Infected, fully recover without treatment	0	50	40	10

For the primary scenario (tularemia, Day 4 following incident), the probabilities of presenting conditions were basically assessed to be the same for both types of infected casualties because of how the agent progresses in the human body. This may not hold true for other BW agents.

4.4 Triage Protocols

Once expectations of the presenting casualty profile were assessed, the Working Group turned to the expected results of the triage processes. Triage protocols provide the means for separating the casualties who should be sent to Treatment and Stabilization from those who should be sent to Outprocessing. The Working Group developed triage protocols and estimates of abnormal incidence of triage indicators for the Initial Triage Area and the Secondary Triage Area.

4.4.1 Initial Triage

The Initial Triage protocol calls for first determining whether the casualty is ambulatory and looks able to go through the normal registration process. If the casualty is not ambulatory or looks too ill to go through registration, the casualty is assessed using the START protocol (respiration, perfusion, and mental status). This initial triage process was termed B-START.

The Working Group estimated the probability that a presenting casualty would be non-ambulatory, given various presenting conditions (Table 9). The Working Group believed that state of infection was not a relevant variable for this assessment.

Table 9: Estimated Non-ambulatory Casualties

Presenting Condition	Probability that a casualty is non-ambulatory (percent)
Dead on Arrival	100
Feeling acutely ill	33
Feeling moderately ill	0
Not feeling ill	0

The Working Group then estimated the probability that a presenting casualty would fail the visual check, given the casualty is ambulatory under various presenting conditions (Table 10).

Table 10: Estimated Casualties Failing the Visual Check

Presenting Condition	Probability of casualty failing visual check, given casualty is ambulatory (percent)
Feeling acutely ill	100
Feeling moderately ill	50
Not feeling ill	0

Finally, the Working Group estimated the probability of an abnormal indication for each of the three START indicators. According to the START triage rules, if a casualty fails the respiration indicator, the casualty is assigned a priority color RED and sent to Treatment and Stabilization. If a casualty passes respiration, but fails perfusion, the casualty is also assigned a priority color RED. If a casualty passes respiration and perfusion, but fails mental status, the casualty is, again, assigned a priority color RED. A casualty who passes all three indicators is assigned a priority color YELLOW. The probabilities in Table 11 reflect the conditional nature of the START process, in that each row shows the probability of failing the indicator, given the casualty passed the indicator in the row before.

Table 11: Estimated Incidence of Abnormal START Indicators

	Probability of an Abnormal START Indicator (percent), given:					
	Ambulatory, but failed visual check				Non-ambulatory	
START Indicators	Not feeling ill	Feeling moder-ately ill	Feeling acutely ill		Feeling acutely ill	
			Not infected	Infected	Not infected	Infected
Respiration	1	1	30	40	85	95
Perfusion	1	3	5	5	60	60
Mental status	1	3	5	5	10	10

For the primary scenario (tularemia, Day 4 following incident), the probabilities of abnormal perfusion and mental status indicators were assessed to be the same for infected and non-infected acute casualties because the agent does not cause any unique bleeding or mental symptoms. This may not hold true for other BW agents.

4.4.2 Secondary Triage

The secondary triage protocol calls for measuring five vital signs and looking for five critical assessment markers. Casualties are assigned a priority color and sent to another area based on a pre-defined triage rule.

The Working Group estimated the probability of an abnormal indication for each vital sign and critical assessment marker, under various states of infection and presenting conditions. These indicators were presumed to be relatively independent from each other. The group's assessments are shown in Tables 12 and 13. Estimates for condition "feeling acutely ill" were not assessed because very few, if any, of these casualties would be sent through the Secondary Triage Area.

Table 12: Estimated Incidence of Abnormal Vital Signs

	Probability of an Abnormal Indicator (percent)			
Vital Signs	Not infected, not feeling ill	Infected, not feeling ill	Not infected, feeling mod. ill	Infected, feeling mod. ill
Temperature	1	2	10	80
Respiratory rate	1	1	5	10
Oxygen saturation	10	15	15	20
Pulse rate	5	10	15	20
Blood pressure	30	35	40	45

Table 13: Estimated Incidence of Abnormal Critical Assessment Markers

	Probability of an Abnormal Indicator (percent)			
Critical Assessment Markers	Not infected, not feeling ill	Infected, not feeling ill	Not infected, feeling mod. ill	Infected, feeling mod. ill
Alertness	1	1	2	2
Photophobia	1	1	2	2
Stiff neck	1	5	2	10
Breathing	1	2	3	5
Chest pain	0	0	5	5

4.5 Treatment Protocols

The Working Group developed treatment protocols and casualty disposition estimates for the Treatment and Stabilization Area and the Observation/Holding Area. The purpose of these estimates is to establish the expected effectiveness of the treatment protocols, meaning the expected number of casualties who will need continued treatment and the expected number who can return home with medications.

4.5.1 Treatment and Stabilization Area

The treatment protocol in the Treatment and Stabilization Area calls for a balance between minimal stabilization of potentially infected acutely ill casualties and emergency room capabilities broad enough to handle a range of life-threatening conditions and injuries. The treatment protocols include ACLS/ATLS/PALS, burn management, intravenous antibiotics, and fluid replacement regime. Treatment in this area will last between 15 and 45 minutes.

The Working Group estimated the probability of a casualty's priority when leaving the Treatment and Stabilization Area, given they entered as priority RED (ambulatory or non-ambulatory) or YELLOW (Table 14).

Table 14: Estimated Disposition from Treatment and Stabilization

Disposition (percent)	Casualty entered as non-ambulatory RED	Casualty entered as ambulatory RED	Casualty entered as YELLOW
Leave as RED	74	64	10
Leave as YELLOW	20	30	60
Leave as GREEN	1	2	29
Leave as BLACK	5	4	1

4.5.2 Observation/Holding Area

Once casualties are stabilized, they will be transferred from the Treatment and Stabilization Area to the Observation/Holding Area. The primary treatment protocol in the Observation/Holding Area calls for continuing to administer fluids and/or antibiotics. If a casualty is well enough to return home, he or she will report to the Outprocessing Area. Casualties who need additional medical care will be transferred to the ACC. The treatment in this area will last between 45 minutes and one hour.

The Working Group estimated the probability of a casualty's priority when leaving the Observation/Holding Area, given they entered as priority RED or YELLOW (Table15).

Table 15: Estimated Disposition from Observation/Holding

Disposition (percent)	Casualty entered as RED	Casualty entered as YELLOW
Leave as RED	60	9
Leave as YELLOW	35	50
Leave as GREEN	2	40
Leave as BLACK	3	1

The Working Group assumed that the Treatment and Stabilization protocol would result in the re-prioritization of about 30 percent of priority YELLOW casualties to priority GREEN. The Observation/Holding protocol would result in 40 percent of priority YELLOW casualties "going GREEN." Assuming these casualties would be discharged and return home, the Working Group clearly believes that treatment protocols will have a significant impact on casualty disposition.

4.6 Treatment Efficacy

Treatment Efficacy measures the percent reduction of deaths (mortality) and the percent reduction in effects or duration of illness (morbidity) due to casualty processing through the NEHC.

The Working Group first estimated the probability of the NEHC saving the life of a casualty who eventually would die without treatment, given a particular state of infection and presenting condition (Table 16). These estimates can be multiplied by the expected presenting casualty population to find the overall expected reduction in mortality resulting from the NEHC processes and protocols. The estimates only apply to the primary scenario.

Table 16: Estimates of Mortality Reduction

Condition/State	Probability of Saving Casualty Life (percent)
Infected, Not feeling ill	85
Infected, Moderately ill	70
Infected, Acutely ill	55
Not infected, Not feeling ill	100
Not infected, Moderately ill	100
Not infected, Acutely ill	55

The Working Group then estimated the probability of the NEHC reducing the effects or duration of illness of a casualty, given a particular state of infection and presenting condition (Table 17). These estimates can be multiplied by the expected presenting casualty population to find the overall expected reduction in morbidity resulting from the NEHC processes and protocols. Again, the estimates only apply to the primary scenario.

Table 17: Estimates of Morbidity Reduction

Condition/State	Probability of reducing effects for casualties who would not die (percent)	Probability of reducing effects for casualties who would die (percent)
Infected, Not feeling ill	90	90
Infected, Moderately ill	80	80
Infected, Acutely ill	20	20
Not infected, Not feeling ill	100	100
Not infected, Moderately ill	90	100
Not infected, Acutely ill	90	90

4.7 MOE weights

The Working Group also provided relative weights for the MOEs to be used to combine the MOEs into an overall measure of validity in the Multiple Criteria Decision Model. The MOE hierarchy with weights is shown in Figure 14.

The Working Group used a technique called pairwise comparisons to develop the weights. At each node of the hierarchy, each measure is compared to all the other measures at the same node in terms of relative importance. The resulting comparisons are normalized to sum to 1.

The Working Group clearly believed that the most important attributes of the NEHC design are throughput, cycle time (to ACC and to Home) and mortality reduction. Those four MOEs make up nearly 70% of the overall importance.

The Working Group then reviewed the process flowchart, simulation model, probability trees, and multiple criteria decision model after these estimates were entered in order to verify the detailed NEHC design.

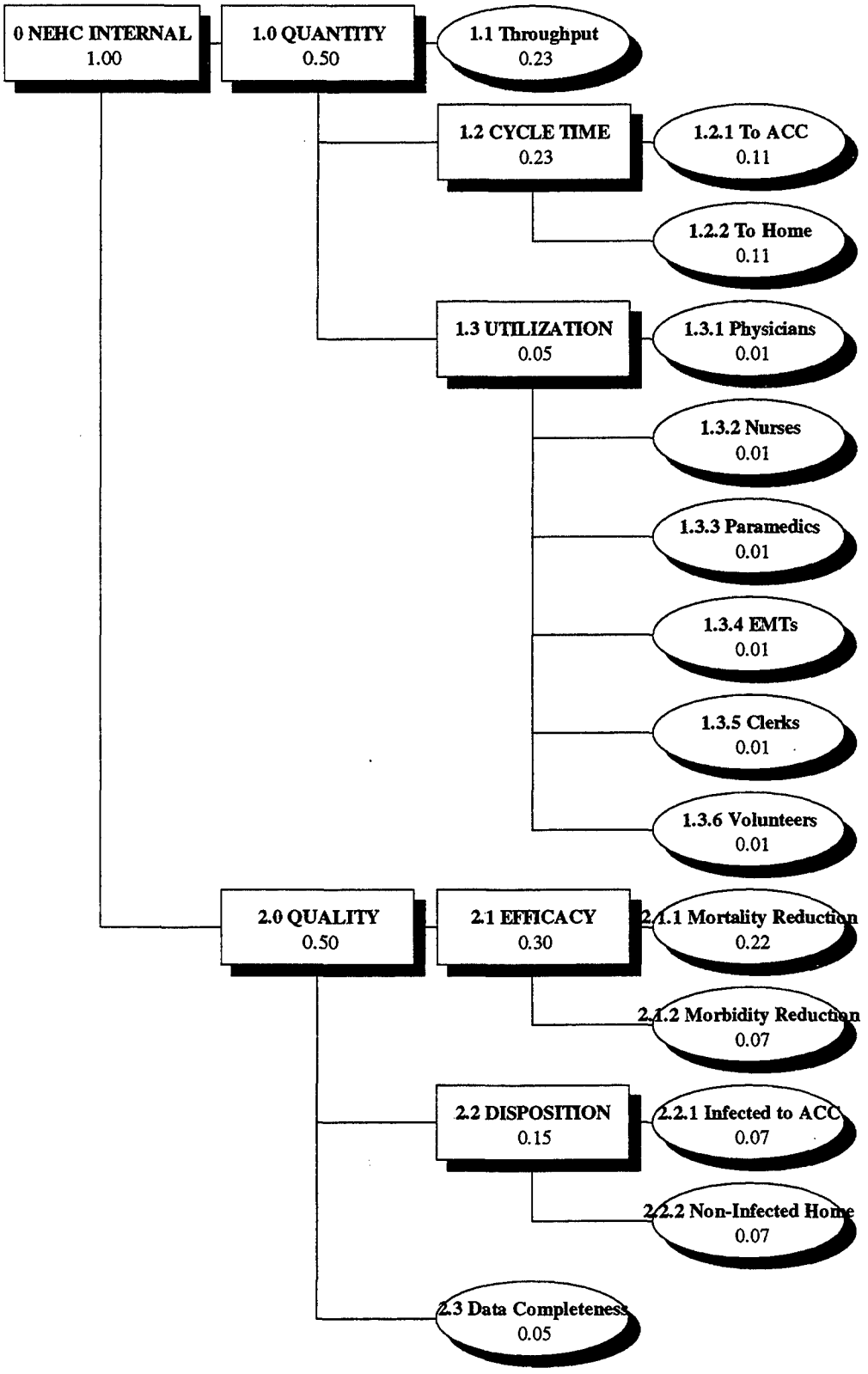


Figure 14: Multiple Criteria Decision Model with Weights

Section

5

5 Triage and Treatment Validation

As discussed in Section 3, the medical impact of triage and treatment procedures on casualties could not be measured by a live exercise. Instead, a desktop exercise evaluation protocol was used to assess and validate the triage and treatment portions of the NEHC design.

The desktop exercise was conducted on September 8, 1999, with a validation panel of independent experts. The panel membership is shown in Table 18.

Table 18: Validation Panel Members

Name	Organization
Dr. Richard Alcorta	MIEMSS
Dr. Henry Siegelson	Disaster Planning International
Dr. Eric Auf der Heide	ATSDR/USDHHS
Dr. Ameen Ramzy	Baltimore County FD
Ms. Myra Socher	Disaster Planning International
Mr. Richard Serino	Boston EMS
Dr. Howard Levitan	Disaster Planning International

The Validation Panel members were presented with a thorough review of the NEHC concept, design, and definitions. However, they were not shown the triage and treatment estimates developed by the Working Group. The Validation Panel was also briefed on the primary scenario. They were then asked to provide their own estimates of the triage and treatment parameters discussed in Section 4, assuming the primary scenario.

The Validation Panel estimates were based on given casualty type "cases," which were a combination of *state of infection* and *presenting condition.*

- Type A - Infected & Acutely Ill
- Type B - Not Infected & Acutely Ill
- Type C - Infected & Moderately Ill
- Type D - Not Infected & Moderately Ill
- Type E - Infected & Not Feeling Ill
- Type F - Not Infected & Not Feeling Ill

Ventana *GroupSystems,* a portable local area network (LAN), was used to solicit individual, independent estimates from the panel members and compile the initial results. The system allowed meeting participants to provide individual, anonymous input using notebook computers while a facilitator guided the group discussion. Individual and average results were displayed to the group via projector, and divergent results were then discussed to reach consensus among the panel members.

The results of the Validation Panel were compared after the exercise to the Working Group's results. In the following tables, the Working Group (WG) estimates are shown next to the Validation Panel (VP) estimates. A green checkmark ☑ next to a WG estimate indicates that the estimate was validated. A red X ☒ indicates that the estimate was not validated. Generally, the WG estimate was not validated if the VP estimate was 15 percentage points higher or lower.

5.1 Triage Protocols

5.1.1 Initial Triage

The Validation Panel estimated the probability that a presenting casualty would be non-ambulatory, given various presenting conditions (Table 19).

Table 19: Validation of Non-ambulatory Casualties

Presenting Condition	Probability that a casualty is non-ambulatory (percent)	
	VP	WG
Dead on Arrival	100	100 ☑
Feeling acutely ill	10	33 ☒
Feeling moderately ill	0	0 ☑
Not feeling ill	0	0 ☑

The VP felt that most non-ambulatory casualties would not able to get to the NEHC or would call 911 and then be taken to a hospital, so the percent of non-ambulatory casualties presenting to the NEHC would be very low.

The VP then estimated the probability that a presenting casualty would fail the visual check, given the casualty is ambulatory under various presenting conditions (Table 20).

Table 20: Validation of Casualties Failing the Visual Check

Presenting Condition	**Probability of casualty failing visual check, given casualty is ambulatory (percent)**	
	VP	**WG**
Feeling acutely ill	75	90 ☒
Feeling moderately ill	15	50 ☒
Not feeling ill	0	0 ☑

The VP believed that the NEHC would maintain a lower standard of care than a normal emergency room, and ambulatory casualties would *really* have to look sick to be sent directly to treatment. The WG believed that if a casualty is *feeling* acutely ill then he or she will *look* ill and should go directly to treatment.

The VP then estimated the probability of an abnormal indication for each of the three START indicators (Table 21).

Table 21: Validation of Incidence of Abnormal START Indicators

	Probability of an Abnormal START Indicator (percent), given:					
	Ambulatory, but failed visual check				Non-ambulatory	
START Indicators	Types E/F Not feeling ill	Types C/D Moder-ately ill	Type B Not infected, feeling acutely ill	Type A Infected, feeling acutely ill	Type B Not infected, feeling acutely ill	Type A Infected, feeling acutely ill
	VP/WG	VP/WG	VP/WG	VP/WG	VP/WG	VP/WG
Respiration	7/1 ☑	43/1 ☒	65/30 ☒	75/40 ☒	75/85 ☑	75/95 ☒
Perfusion	3/1 ☑	17/3 ☑	35/5 ☒	10/5 ☑	57/60 ☑	75/60 ☒
Mental status	2/1 ☑	7/3 ☑	10/5 ☑	6/5 ☑	18/10 ☑	6/10 ☑

The WG believed that if casualties are ambulatory and only feeling moderately ill, they will almost certainly be breathing at a normal rate. However, the VP stressed the fact that these ambulatory casualties failed the visual check, and it believed that the main reason an ambulatory casualty would fail the visual assessment is due to respiratory abnormality. The VP also believed that the main reason a casualty will fail the visual assessment *if they pass the respiratory assessment* is perfusion abnormality.

5.1.2 Secondary Triage

The VP estimated the probability of an abnormal indication for each vital sign (Table 22) and critical assessment marker (Table 23).

Table 22: Validation of Incidence of Abnormal Vital Signs

	Probability of an Abnormal Indicator (percent)			
Vital Signs	Type F Not infected, not feeling ill	Type E Infected, not feeling ill	Type D Not infected, feeling mod. ill	Type C Infected, feeling mod. ill
	VP/WG	VP/WG	VP/WG	VP/WG
Temperature	0/1 ☑	9/2 ☑	20/10 ☑	76/80 ☑
Respiratory rate	0/1 ☑	3/1 ☑	12/5 ☑	50/10 ☒
Oxygen saturation	0/10 ☑	3/15 ☑	7/15 ☑	27/20 ☑
Pulse rate	0/5 ☑	4/10 ☑	18/15 ☑	50/20 ☒
Blood pressure	1/30 ☒	1/35 ☒	8/40 ☒	23/45 ☒

The VP believed that many casualties, infected or not, will be extremely anxious because of the possibility of a BW infection, causing a high incidence of abnormal respiration and pulse rate. The VP also noted that some of the symptoms of tularemia can cause an abnormal pulse rate in those casualties actually infected.

The WG noted that in the general population, the number of people with high blood pressure will cause a high incidence of abnormal blood pressure readings, even if the BW agent does not affect blood pressure. The VP did not confirm this assumption.

Table 23: Validation of Incidence of Critical Assessment Markers

	Probability of an Abnormal Indicator (percent)			
Critical Assessment Markers	Type F Not infected, not feeling ill	Type E Infected, not feeling ill	Type D Not infected, feeling mod. ill	Type C Infected, feeling mod. ill
	VP/WG	VP/WG	VP/WG	VP/WG
Pupillary Reaction	0/1 ☑	0/1 ☑	0/2 ☑	0/2 ☑
Photophobia	0/1 ☑	0/1 ☑	1/2 ☑	1/2 ☑
Stiff neck	0/1 ☑	0/5 ☑	1/2 ☑	1/10 ☑
Breathing	0/1 ☑	3/2 ☑	11/3 ☑	33/5 ☒
Chest pain	0/0 ☑	0/0 ☑	9/5 ☑	24/5 ☒

The VP believed that Pupillary Reaction was not an appropriate triage indicator for secondary triage because anyone with an abnormal pupillary reaction would be near death and have already been sent to treatment. This marker was changed to "Alertness" after the test by the WG.

The VP believed that the high anxiety in many casualties will also cause a high incidence of difficult breathing.

The WG believed that chest pain is an acute symptom not a moderate symptom. The VP did not confirm this assumption.

5.2 Treatment Protocols

5.2.1 Treatment and Stabilization Area

The VP estimated the probability of a casualty's priority when leaving the Treatment and Stabilization Area, given they entered as priority RED (the VP made no distinction between ambulatory or non-ambulatory) or YELLOW (Table 24). The VP assumed few or no casualties died during treatment.

Table 24: Validation of Disposition from Treatment and Stabilization

Disposition (percent)	Casualty entered as non-ambulatory RED	Casualty entered as ambulatory RED	Casualty entered as YELLOW
	VP/WG	VP/WG	VP/WG
Leave as RED	65/74 ☑	65/64 ☑	15/10 ☑
Leave as YELLOW	30/20 ☑	30/30 ☑	50/60 ☑
Leave as GREEN	5/1 ☑	5/2 ☑	35/29 ☑
Leave as BLACK	0/5 ☑	0/4 ☑	0/1 ☑

5.2.2 Observation/Holding Area

The VP estimated the probability of a casualty's priority when leaving the Observation/Holding Area, given they entered as priority RED or YELLOW (Table 25). The VP assumed few or no casualties died during treatment.

Table 25: Validation of Disposition from Observation/Holding

Disposition (percent)	Casualty entered as RED	Casualty entered as YELLOW
	VP/WG	VP/WG
Leave as RED	75/60 ☑	15/9 ☑
Leave as YELLOW	20/35 ☑	65/50 ☑
Leave as GREEN	5/2 ☑	20/40 ☒
Leave as BLACK	0/3 ☑	0/1 ☑

The VP believed that the liability of sending someone home before they are really ready to go home is too high. Also, the IV is not going to improve a dehydrated casualty to a great extent in a time period of less than an hour. The WG believed that most of the ill casualties will simply be dehydrated, so a bag or two of fluids or some oxygen will probably make them well enough to go home. The VP did not confirm this assumption.

5.3 Treatment Efficacy

There are two measures for treatment efficacy: reduction in mortality and reduction in morbidity. The VP only provided assessments for mortality. The VP members did not believe they could make informed estimates for morbidity reduction.

The VP estimated the probability of the NEHC saving the life of a casualty who eventually would die without treatment, given a particular state of infection and presenting condition (Table 26).

Table 26: Validation of Mortality Reduction

	Probability of Saving Casualty Life (percent)	
Condition/State	Validation Panel	Working Group
Not feeling ill, infected	90	85 ☑
Moderately ill, infected	75	70 ☑
Acutely ill, infected	40	55 ☒
Not feeling ill, not infected	100	100 ☑
Moderately ill, not infected	45	100 ☒
Acutely ill, not infected	25	55 ☒

The VP believed that the NEHC protocols would not be as effective for acutely ill casualties as the WG estimate. The VP also believed that for moderately/acutely ill casualties who were not infected, the NEHC would not have the equipment and resources, including quantity of staff and correct staff skills, to handle non-BW illnesses and traumas. Again, the VP saw the NEHC as a lower standard of care facility.

5.4 Reneging Rates

The Validation Panel estimated the probabilities that casualties presenting with various conditions will give up and walk out of the NEHC facility if they have to wait too long for service. This behavior is known as reneging.

Although reneging behavior is difficult to predict, assumptions about the expected reneging rates can have a significant impact on the effectiveness and efficiency of a facility providing medical services. The Working Group assumed that reneging might occur in the Initial Triage and Registration Areas, but did not assess probabilities. Since it is unlikely that presenting casualties will have to wait more than a few minutes at Initial Triage, estimates were requested from the VP only for Registration. These estimates are shown in Table 27.

Table 27: Estimated Reneging Rates at Registration Area

	Probability of leaving Registration Area without service (percent):		
	Acutely ill	Moderately ill	Not feeling ill
After waiting 1 hour	0	8	10
After waiting 2 hours	1	22	23
After waiting 4 hours	4	22	25
After waiting 8 hours	7	22	21
Probably won't leave	88	26	21

Research in the disaster medicine literature found no empirical data on reneging in similar situations that could be compared to the VP estimates, and resources were not available to conduct an independent survey. However, the risk to validity of the NEHC concept under the primary scenario is low because extended waiting times are not likely. If the type of BW agent or the pattern of presenting casualties is changed, reneging rates may take on increased significance.

5.5 Triage and Treatment Validation Summary

Overall, there was reasonable agreement between the Working Group and the Validation Panel. Where there were differences, the rationale behind the differences was documented, as described above. The resulting scores for each MOE are shown in Section 7.

The Validation Panel also provided over 30 comments and suggestions for improvements to the NEHC design and the BWIRP. These were carefully considered and some incorporated into the program.

Finally, the VP had a major concern over the lack of actual data on which to base the NEHC design. They felt, as a group, that their judgement alone was not sufficient to fully validate the triage and treatment aspects of the NEHC concept. They believed that empirical data was needed, either from prior studies or from new experimentation.

Section

6

6 Live Field Test

A two-day live field test was conducted on November 6-7, 1999 at the Edgewood Area Gunpowder Club, Aberdeen Proving Ground, MD. The test design consisted of two, six-hour test periods (Day 1 and Day 2), using Maryland National Guard personnel from the 229th Main Support Battalion as Medical Staff and soldiers from the 16th and 143rd Ordnance Battalions as simulated casualties.

Figure 15: Casualties arriving during the Live Field Test

The purpose of the live test was to validate the facility throughput, casualty cycle time, staff utilization, and data completeness MOEs. This section describes the conduct of the live test and the variances from the test design that may have impacted the validation results.

6.1 Bar Code Data Collection Process

Data from the live field test was collected using bar code technology provided by Work Management Institute (WMI). Bar codes tags were assigned to each staff member, each casualty and each area within the facility. The casualties also were given a hand-held bar code reader, called a wand, which they used to "swipe" the bar code tags when starting and stopping each activity.

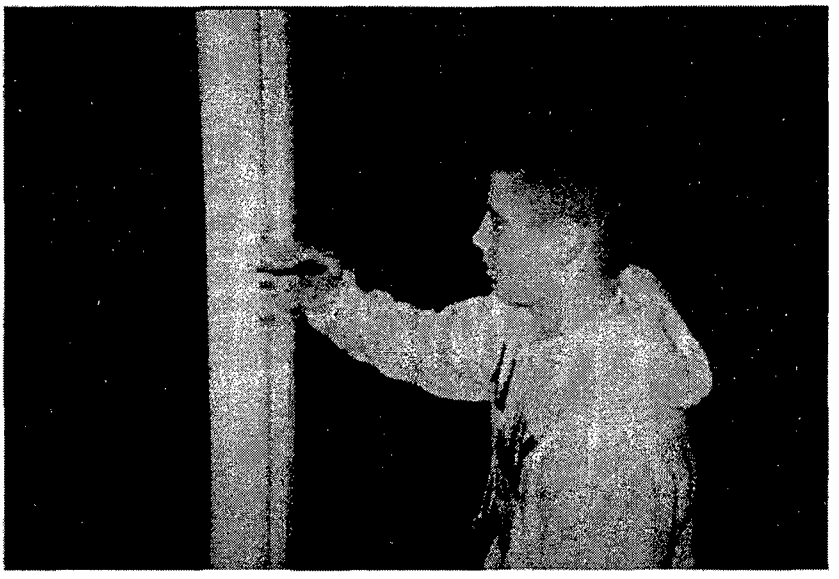


Figure 16: Casualty Using Bar Code Reader

Day 1 used a casualty arrival rate of 42 per hour (1,000 per day). Day 2 increased casualty arrivals by 50 percent to 63 casualties per hour. Data was collected from the beginning of each six-hour test period. However, test data for the first 1.5 hours following StartEx was not used for validation. This was to account for the ramp up, or start up, time needed to bring the NEHC to steady state operations.

The test was ended after 5.25 hours on Day 1 and ran the full 6 hours on Day 2. However, casualties stopped entering the facility after 4.5 hours on Day 1 and after 3.5 hours on Day 2. This was to allow time for all casualties to process through the facility before EndEx. Test data for the time after casualties stopped entering was not used for validation. This provided a 3-hour validation window for Day 1 and a 2-hour window for Day 2. These start-end window times are shown in Table 28.

Table 28: Data Capture Windows

	Day 1	Day 2
StartEx (casualties start entering NEHC)	12:45 p.m.	9:40 a.m.
Start test data (reached steady state)	2:15 p.m.	11:10 a.m.
End test data (stop casualties entering)	5:15 p.m.	1:10 p.m.
EndEx (all casualties processed through)	6:00 p.m.	3:40 p.m.

6.2 NEHC Features Not Tested

6.2.1 Support Staff

The NEHC design has 69 casualty care staff and also has 4 security, 2 housekeepers, and 7 additional operations staff, for a total of 82 staff. Of the 69 casualty care staff, 8 positions were not tested, leaving 61 casualty care staff positions actually tested during the live exercise. Table 29 shows the positions not tested.

Table 29: Staff Positions Not Tested

Areas not Tested	Clerks	Volunteers
Temporary Morgue	1	1
Supply Area	1	2
Operations Area	1	
External Transportation	1	1

6.2.2 Family Units

The NEHC design discusses the need to keep families together and to provide for the special needs of the disabled, children and elderly. No attempt was made to test the adequacy of these procedures.

6.2.3 Mandatory Breaks for Staff

No mandatory breaks were tested.

6.2.4 Shift Changes

Design called for 100% shift changes every 12 hours. No shift change was tested.

6.3 Variances from the NEHC Design

The test was partially flawed because the evaluator/controller staff, NEHC staff and casualty actors did not completely follow the NEHC design. This may have been due to lack of time to adequately train, or due to staff and actors ignoring some design protocols and procedures and substituting their own. The general variances were:

- Some controllers and evaluators served as informal area "coordinators" during the test. In particular, during Day 1, there was significant interaction with staff in

Secondary Triage, Treatment and Stabilization, and Observation/Holding. This effectively provided additional staff to the NEHC.

- Controllers did not enforce the clerk-to-volunteer staff ratios in the Registration and Discharge areas. This may have reduced the quality of casualty services in those areas and freed up clerks for other assignments.

- NEHC training was not detailed enough for some staff, and some staff members were not trained at all. In particular, the staff was not trained on how to fill out the patient forms, resulting in many incomplete forms.

- Some NEHC procedures were not explained correctly by test controllers and evaluators to the test participants during training on the first day of the test.

- Test "StartEx" was not appropriately announced to all stations on the first day of the test. Some staff were told to swipe their bar code reader at the start of the test, instead of when they had a casualty to treat. This may have resulted in some inaccurate staff utilization times.

Variances occurring with staffing, casualty cards, and within each NEHC area are discussed in the following sub-sections.

6.3.1 Facility Staffing

A test departure from the NEHC concept design was a variance in the number of NEHC staff due to a lack of personnel available to participate. The test design called for 61 staff. On Day 1, the NEHC staff was short one volunteer. On Day 2, the NEHC staff was short two volunteers. This shortage may have caused higher than expected staff utilization.

6.3.2 Casualty Cards

The 300 casualty cards generated for the live exercise did not match the test plan. There were several problems including:

- Casualty mix. A large number of the cards described trauma symptoms instead of symptoms consistent with the BW scenario.

- Treatment times. Treatment times were not specified on the cards as required by the test design. Treatment times were added to the cards before StartEx. However, due to the descriptions of the symptoms, the times associated did not always make sense, but were necessary for the design to be tested effectively.

- Initial triage dispositions. The disposition percentages were incorrect. This was not corrected before Startex. The cards had a higher percentage of priority RED/YELLOW at initial triage. The test design called for a higher percentage of priority GREEN at initial triage. This caused fewer casualties than expected to be sent to Registration and Secondary Triage (Table 30).

Table 30: Disposition from Initial Triage for Day 1

	Casualty cards called for in test design	Casualty cards used in Live Field Exercise
Black	1	1
Red	35	47
Yellow	50	58
Green	90	70
TOTAL	176	176

6.3.3 Initial Triage

- The Initial Triage area had an extra EMT at the entrance to the NEHC. This person was nominally a security guard, but the person assisted in the triage process.

6.3.4 Registration

- The clerks at registration set up a separate table and required the casualties to stop there after being registered by a volunteer. This added a second step in the process. The NEHC design concept called for a one-step method with an "over the shoulder" check by a registration clerk.

- On Day 2, registration clerks picked up their assigned bar code tags and wands, but did not play in the exercise. Consequently, there are no data for registration clerks for Day 2.

6.3.5 Secondary Triage

- The primary method for categorizing casualties in secondary triage uses a point scale. The test used the alternate method for categorizing casualties, which is a go/no go system. The test design called for the go/no go protocol to require that 2 abnormal vital signs and 1 abnormal critical assessment marker be found to indicate priority RED, and 1 abnormal critical assessment marker and 1 abnormal vital sign be found to indicate priority YELLOW. The NEHC Concept draft in the test handbook and the patient forms state that only 2 abnormal vital signs are needed to indicate priority RED. This potential change in protocol could cause a large increase in the number of casualties expected to be sent to the ACC.

6.3.6 Treatment and Stabilization Area

- Casualties were "double slotted" to reduce the waiting time that casualties had to wait for treatment on Day 2. One casualty was placed in the bed and another casualty placed in a chair in the same treatment station. This required treatment teams to handle more than 5 casualties at a time, the limit stated in the NEHC concept.

- There was no volunteer assigned in the treatment waiting area. This meant that some casualties may have been left alone while waiting for treatment, reducing quality of care.

- Some casualties were not held in treatment as long as their casualty card directed. This means that some casualty cycle times in the test may be shorter than expected.

- The internal transportation clerk collected the bar code wands from each volunteer as well as the bar code tag after the volunteer finished an assignment. This meant that some volunteers may have been re-issued someone else's bar code wand during the test.

- Some casualties were removed from their bed before internal transportation had arrived to take the casualty to the next area. This may have freed up bed space prematurely, increasing facility throughput above the expected rate.

- There were not enough wheelchairs. This meant that some casualties may have waited for equipment, even when staff was available, increasing casualty cycle time above the expected rate.

6.3.7 Observation and Holding

- Nurses in some cases ignored the casualty disposition as stated on the casualty card and sent the casualty to outprocessing. This was assumed to have been done because the casualty symptoms were not scenario based.

6.3.8 Outprocessing - Briefing, Medications, Discharge

- In the mass briefing, the nurse did not give the briefing to whoever was waiting, but rather the nurse waited until a number of casualties where waiting in the waiting area. This caused the average wait time per casualty to be higher than it should have been.

- There was little or no information on the patient forms of casualties who processed through the discharge station. This indicates that the staff was not trained in this responsibility.

- There was no clerk assigned to the discharge area as required in the NEHC design. This may have freed up a clerk to perform other activities.

6.4 Internal Transit Times

The validation of the NEHC concept is largely independent of the actual layout of the building chosen for the facility. However, the time it takes to move casualties between areas within the facility may change significantly, depending on how spread out the areas are from each other, and how many floors of the building are used.

The internal transit times measured in the facility used for the test were significantly lower than the nominal times developed by the Working Group. This makes sense because the Edgewood Gunpowder Club used for the test is a very compact facility.

In order to remove the impact of differences in facility layout, the live field test times for internal transit were used in the simulation model to develop expected casualty cycle times. These internal transit times are shown in Table 31.

Table 31: Internal Transit Times

	Nominal (minutes)	Day 1 (minutes)	Day 2 (minutes)	Average used in simulation
Initial to registration	1	.2	.3	.25
Initial to treatment (non-ambulatory/ambulatory)	4-10	.9	.2	.5
Registration to secondary	1	.5	.8	.7
Secondary to treatment	10	1.5	1.8	1.7
Secondary to outprocessing	3	.9	1.2	1
Treatment to observation	5	.7	1	.8
Treatment to outprocessing	3	.9	1.3	1
Outprocess to exit	1	.1	.2	.15
Observation to outprocessing	3	.9	1.1	1
Observation to exit/ACC	5	.3	3.3	1.6

6.5 External Transportation Schedule

The NEHC concept assumes that transportation from the NEHC to the ACC is provided by the Casualty Relocation Unit (CRU), which is a separate component of the MEMS. The concept assumes that one bus and one ambulance are assigned to support each NEHC.

The bus is assumed to make a roundtrip every 100 to 120 minutes with 18-22 casualties. The ambulance is assumed to make a roundtrip every 50 to 60 minutes with 2 –3 casualties. Based on StartEx, the transportation schedule used for the test for vehicles arriving at the NEHC to take casualties to the ACC is shown in Table 32.

Table 32: External Transportation Schedule

	Minutes after Startex	**Day 1 Arrival Times**	**Day 2 Arrival Times**	**Number of casualties (capacity)**
StartEx	0	12:45 pm	9:40 am	
Ambulance	55 min	1:40	10:35	2
Bus	110 min	2:35	11:30	20
Ambulance	115 min	2:40	11:35	3
Ambulance	165 min	3:30	12:25	2
Bus	210 min	4:15	1:10	22
Ambulance	220 min	4:25	1:20	3
Ambulance	280 min	5:25	2:20	2
Bus	315 min	6:00	2:45	18
Ambulance	335 min	6:20	3:15	2

Section

7

7 Validation Results

The following table shows a summary of the validation testing results.

Table 33: Validation Testing Results

Measures of Effectiveness	Day 1			Day 2		
	Expected Performance	Validation Panel Results	Live Field Test Results	Expected Performance	Validation Panel Results	Live Field Test Results
1.0 Quantity						
1.1 Facility Throughput (per hr)	42	--	38.6	42	--	43
1.2 Casualty Cycle Time						
1.2.1 To ACC (minutes)	83	--	64.2	74	--	50
1.2.2 To Home (minutes)	49	--	43.1	48	--	42.8
1.3 Staff Utilization						
1.3.1 Physicians (% time)	89	--	89	95	--	90
1.3.2 Nurses (% time)	86	--	86	94	--	67
1.3.3 Paramedics (% time)	83	--	90	99	--	100
1.3.4 EMTs (% time)	62	--	54	87	--	62
1.3.5 Clerks (% time)	90	--	55	96	--	90
1.3.6 Volunteers (% time)	67	--	46	77	--	63
2.0 Quality						
2.1 Treatment Efficacy						
2.1.1 Mortality (% reduction)	60	50	--	60	50	--
2.1.2 Morbidity (% reduction)	62	not tested	--	62	not tested	--
2.2 Triage Disposition						
2.2.1 Non-infected to Home (%)	96	97	--	96	97	--
2.2.2 Infected to ACC (%)	43	54	--	43	54	--
2.3 Data Completeness (% items)	100	--	not tested	100	--	not tested

7.1 Facility Throughput

The live field test gathered data for 3 hours of operation at a steady state on Day 1, and 2 hours on Day 2. The expected numbers of throughput casualties during these windows are 41.7 per hour, or 125 and 83, respectively. Table 34 shows that results from the test are within 7 percent of the expected facility throughput.

Table 34: Throughput Results Comparison

	Number of throughput casualties			
	Expected Day 1 in 3 hrs.	Test Day 1 in 3 hrs.	Expected Day 2 in 2 hrs.	Test Day 2 in 2 hrs.
To Home	80	76	53	59
To ACC	44	40	29	26
To Morgue	1	0	1	1
Total	125	116	83	86

7.2 Casualty Cycle Time

Cycle time is dependent partially on the particular facility layout. Therefore, internal transit times were normalized by putting the average transit times from the live test in the simulation model before estimating the expected casualty cycle times.

Average casualty cycle time results from the test were calculated only from the data of those casualties who entered and exited the facility within the "steady state" window.

Table 35 shows that predicted cycle times for casualties being sent to the ACC are significantly greater than the test results on both Day 1 and Day 2 (2 hour window).

Table 35: Casualty Cycle Time

	Average casualty cycle time (minutes)					
Casualties sent:	**Expected Day 1 3 hr. window**	**Test Day 1 3 hr. window**	**Expected Day 2 2 hr. window**	**Test Day 2 2 hr. window**	**Test Day 2 3 hr. window**	**Test Day 2 3.5 hr. window**
To ACC	83	64.2	74	50.0	83.2	87.4
To Home	49	43.1	48	42.8	54.5	66.2

Part of the difference between the expected cycle time for casualties sent to the ACC and the test results may be explained by the fact that some casualties were not held in the treatment area by the staff as long as the casualty card directed, especially on Day 1. Also, in both the treatment and observation areas, the data show that there may have been some cases of incorrect use of the bar code readers by staff and casualties.

On Day 2, the waiting queue for casualties at the Treatment Area was building significantly when the "stop entering casualties" decision was made 3.5 hours into the exercise. This decision was made because the increased rate of presenting casualties was clearly overwhelming the facility. For the first few hours of steady state operation, cycle times are similar to Day 1.

However, because the increased casualty presentation rate was not sustainable, casualties directed to the ACC would have to wait longer and longer in the facility as the day progressed. The window for data collection was extended to 3 hours and then to 3.5 hours to see when the average cycle times would begin to increase. This is shown in Table 35.

7.3 Staff Utilization

Staff utilization is the percent of time that a staff member spends with casualties or performing necessary supporting activities. Table 36 shows that test results are similar to expected utilization percentages, except for clerks on Day 1, nurses on Day 2, and volunteers on both days.

Figure 17: Medical staff providing treatment to a casualty

Table 36: Staff Utilization

	Day 1 Expected	Day 1 Test	Day 2 Expected	Day 2 Test
Physicians	89	89	95	90
Nurses	86	86	94	67
Paramedics	83	90	99	100
EMTs	62	54	87	62
Clerks	90	55	96	90
Volunteers	67	46	77	63

Overall, staff utilization was expected to be higher on Day 2 because of the large number of presenting casualties. Part of the difference between the expected staff utilization for clerks and volunteers and the test results may be explained by the fact that fewer than expected casualties were initially triaged GREEN (because of casualty card problems) and, therefore, the clerks and volunteers at the Registration Area were idle some of the time. On Day 1, these idle staff members were not shifted by the medical director to areas where they could have been better utilized. Another reason for the difference for clerks may be because the Registration clerks on Day 1 established a "check-off" procedure whereby they were not continuously monitoring the work of the volunteers in registering casualties. Instead, they sat at a separate table and checked off each casualty's form before sending the casualty to Secondary Triage. This may not have required as much time as expected. On Day 2, one registration clerk had 100% utilization because he swiped the bar code at the beginning of the exercise and then did not swipe "stop" until the end of the exercise. The volunteers in the Outprocessing Area also had lower than expected utilization because they did not spend the expected time reviewing the patient form with each casualty and answering questions prior to discharge. The difference between the expected staff utilization for nurses and the test results on Day 2 is partially explained by the actions of the mass briefing nurse, who began waiting until a briefing room was full before giving the next briefing.

7.4 Treatment Efficacy

Treatment efficacy measures the expected reduction in mortality and morbidity against the assessed reduction by the Validation Panel. The live field test was not involved in validating these MOEs, therefore, there is no difference between Day 1 and Day 2 results.

Treatment efficacy was modeled using probability trees. The Working Group first assessed the probabilities of reducing mortality and morbidity for different casualty types (see Tables 16 and 17 in Section 4). The assessments were then combined in probability trees.

In Figure 8, shown in Section 3, the likelihood of a presenting casualty surviving the incident (1 – mortality rate) was calculated based on the Working Group assessments. Without the NEHC triage and treatment protocols, the Working Group believed that about 90 percent of the presenting casualties will survive. However, given the expected distribution of infected casualties and their presenting conditions, the Working Group assessed a 96 percent survival rate with the NEHC. This represents a 60 percent reduction in fatalities.

Figure 18 shows the results of the assessments provided by the Validation Panel for mortality. The Working Group estimated that 90 percent of presenting casualties will live without any intervention (follow the branch to No-NEHC). By combining the assessments provided by the Validation Panel, the panel believes that expected reduction would be 95 percent. This equates to a 50% reduction in mortality.

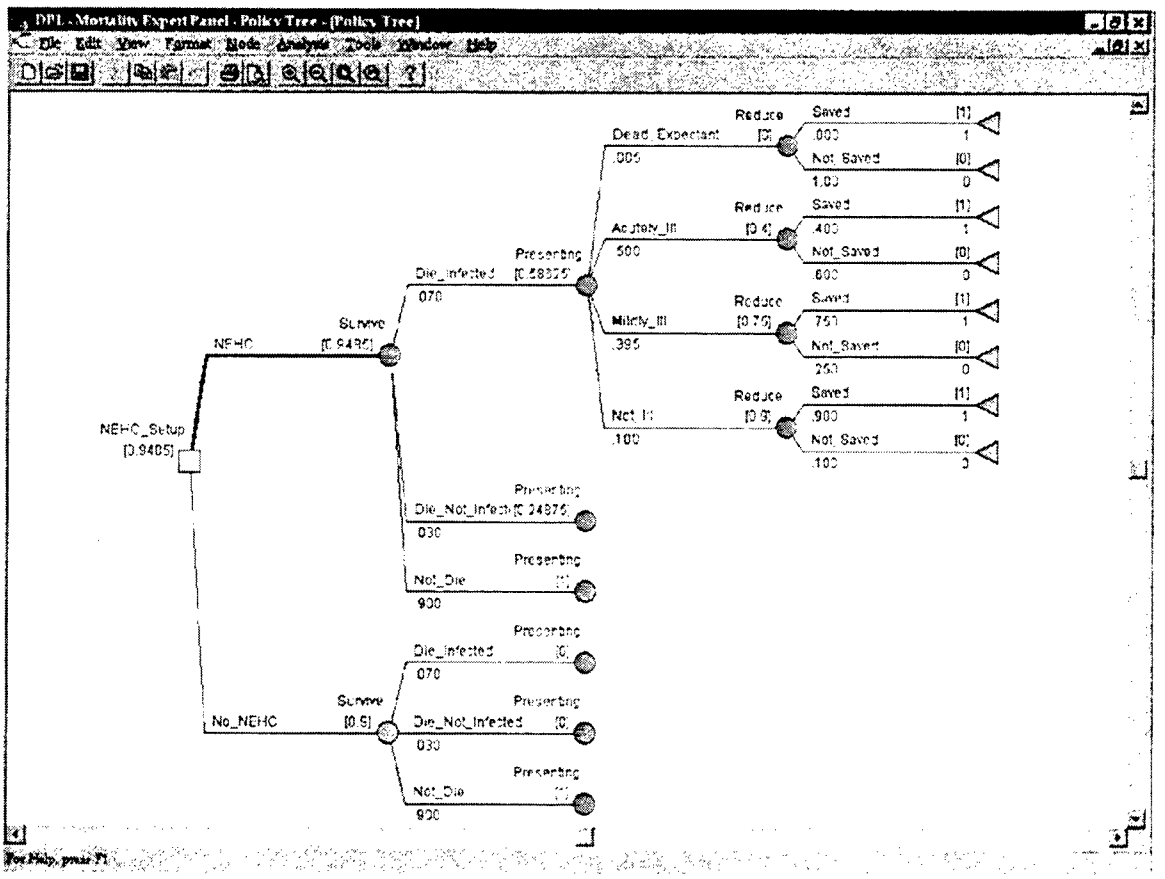


Figure 18: Validation of Mortality Reduction

The Validation Panel did not assess morbidity, so there is no validity measure for it. The Working Group's expected reduction is shown in Figure 19. The branch "No_NEHC" shows that there would be a "0" baseline improvement in morbidity

without an intervention facility like the NEHC. The branch "NEHC" shows a 62 percent improvement to the MOE.

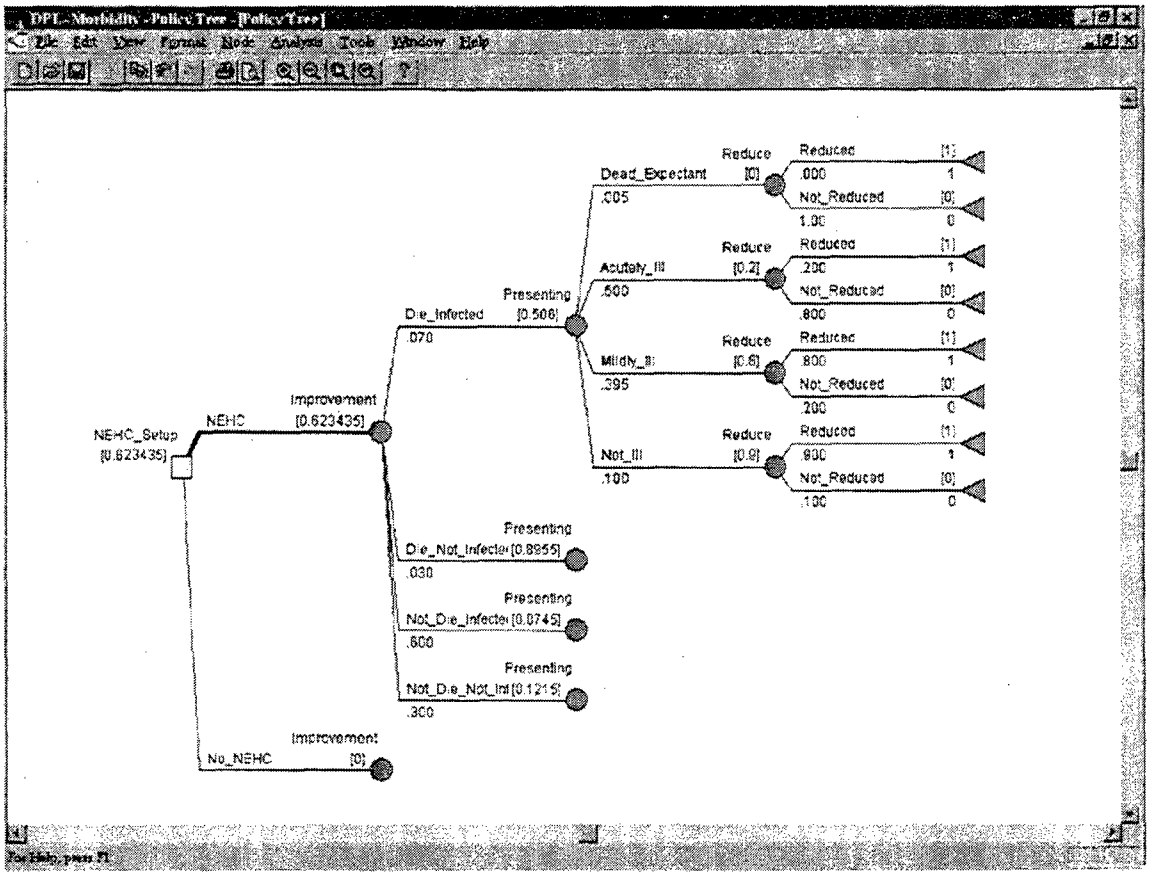


Figure 19: Estimated Morbidity Reduction

The Validation Panel confirmed the likely reduction in mortality that can be expected from the NEHC concept. However, the Validation Panel was slightly more pessimistic in the efficacy of the treatment protocols.

7.5 Triage Disposition

Triage disposition is the percentage of BW agent-infected casualties sent to the ACC and the percentage of non-infected casualties sent home. The initial and secondary triage protocols primarily determine the disposition of casualties. The treatment protocols have a secondary impact on disposition in that a portion of treated casualties may recover sufficiently while in the NEHC that they may return home.

The Working Group estimated the probability of abnormal triage indicators in the Initial and Secondary Triage Areas and the casualty disposition estimates from the Treatment and Stabilization Area and the Observation/Holding Area (see Section 5). These estimates were combined in the Extend simulation model to predict the final disposition of the exiting casualties (Table 37).

Using the probability of abnormal triage indicators and treatment/observation dispositions from the Validation Panel (see Section 5), the Extend simulation model was run again, and results shown in Table 37. Note that this MOE was not measured during the live exercise and, therefore, there is no difference between Day 1 and Day 2.

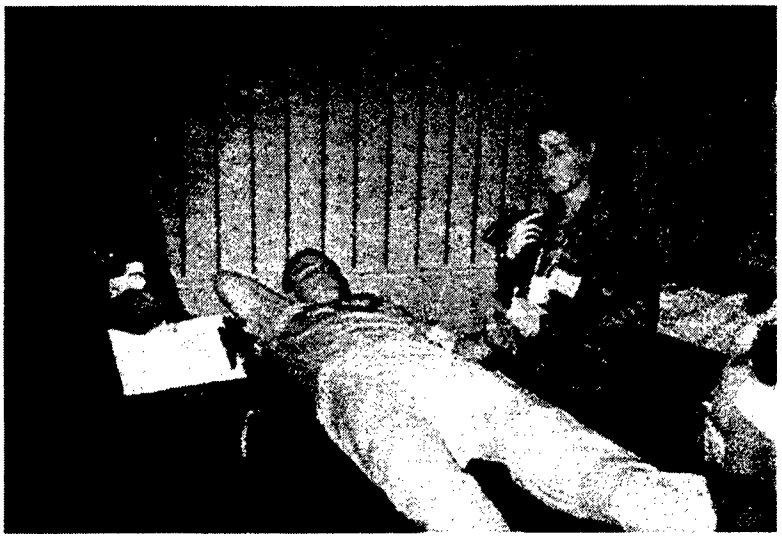


Figure 20: Vital signs being recorded in Secondary Triage

Table 37 : Casualty Disposition

	VP	WG
Percent of infected casualties sent to ACC	54%	43 %
Percent of non-infected casualties sent home	97 %	96 %

The Validation Panel believed that a larger portion of presenting casualties would be ambulatory and, of those, a greater percentage would pass the visual check at Initial Triage. This would have the effect of sending more casualties through Secondary Triage and, potentially, return them home.

However, the Validation Panel also believed that the secondary triage indicators would be more diagnostic than the Working Group believed, thus catching more infected casualties there and routing them to treatment and the ACC.

7.6 Casualty Data Completeness

The medical staff insufficiently completed the casualty forms. Many of the casualties were not shown as registered and none of the casualty forms were signed at discharge. The casualty forms may need to be redesigned for easier use in a BW mass casualty situation. Therefore, this MOE was not scored.

7.7 Multiple Criteria Decision Model

The MOEs were combined to produce overall validity scores for the NEHC in the primary scenario and for both trials. Relative weights for each MOE were developed by the Working Group, and a performance scale was used to convert each MOE to a 0 to 100 "utility score." The expected level of each MOE was set to a score of 100 and the minimal acceptable level was set at half the expected level (or double the expected level in the case of cycle time). See Tables 38 and 39.

Table 38: Criteria Weights and Performance Scales for Day 1

Measure of Effectiveness	Weight	Minimum (0 Level)	Day 1 Results	Expected (100 Level)
1.0 Quantity	.50			
1.1 Facility Throughput (per hr)	.225	21	38.6	42
1.2 Casualty Cycle Time	.225			
1.2.1 To ACC (minutes)	.112	166	64.2	83
1.2.2 To Home (minutes)	.112	98	43.1	49
1.3 Staff Utilization	.05			
1.3.1 Physicians (% time)	.008	45	89	90
1.3.2 Nurses (% time)	.008	44	86	88
1.3.3 Paramedics (% time)	.008	43	90	86
1.3.4 EMTs (% time)	.008	34	54	68
1.3.5 Clerks (% time)	.008	47	55	94
1.3.6 Volunteers (% time)	.008	40	46	80
2.0 Quality	.50			
2.1 Treatment Efficacy	.30			
2.1.1 Mortality (% reduction)	.225	30	50	60
2.1.2 Morbidity (% reduction)	.075	31	not tested	62
2.2 Triage Disposition	.15			
2.2.1 Non-infected to Home (%)	.075	48	97	96
2.2.2 Infected to ACC (%)	.075	22	54	43
2.3 Data Completeness (%)	.05	50	not tested	100

Table 39: Criteria Weights and Performance Scales for Day 2

Measure of Effectiveness	Weight	Minimum (0 Level)	Day 2 Results	Expected (100 Level)
1.0 Quantity	.50			
1.1 Facility Throughput (per hr)	.225	21	43	42
1.2 Casualty Cycle Time	.225			
1.2.1 To ACC (minutes)	.112	148	50	74
1.2.2 To Home (minutes)	.112	96	42.8	48
1.3 Staff Utilization	.05			
1.3.1 Physicians (% time)	.008	48	90	95
1.3.2 Nurses (% time)	.008	47	67	94
1.3.3 Paramedics (% time)	.008	49	100	99
1.3.4 EMTs (% time)	.008	44	62	87
1.3.5 Clerks (% time)	.008	48	90	96
1.3.6 Volunteers (% time)	.008	39	63	77
2.0 Quality	.50			
2.1 Treatment Efficacy	.30			
2.1.1 Mortality (% reduction)	.225	30	50	60
2.1.2 Morbidity (% reduction)	.075	31	not tested	62
2.2 Triage Disposition	.15			
2.2.1 Non-infected to Home (%)	.075	48	97	96
2.2.2 Infected to ACC (%)	.075	22	54	43
2.3 Data Completeness (%)	.05	50	not tested	100

The expected levels for casualty cycle times and staff utilization on Day 2 were based on very short simulation model runs (two hours) because longer model runs showed that the increased volume of casualties quickly overwhelmed the facility and would probably result in large numbers of reneging casualties.

The combined multiple criteria model results are shown in Figures 21 and 22. For Day 1, the combined test results from the validation panel exercise and the live field exercise provide a high validity score for the baseline (1000 presenting casualties per day) NEHC concept. Note that the morbidity and data completeness MOEs were not tested.

Ranking for Internal Validity - Day 1

Alternative	Utility
1 Expected Results Day 1	100
2 Testing Results Day 1	96

Figure 21: Multiple Criteria Decision Model Results for Day 1

For Day 2, the test results actually show a slightly better than expected overall validity score when only measured in the two-hour test data window. With the increased casualty presentation rate on Day 2 (1500 presenting casualties per day), the facility throughput and casualty cycle times meet or are better than expected for this two-hour period. However, this pace of activity does not appear to be sustainable.

The validity score begins to decline as the test window is increased to three hours and beyond. This is due to the backlog of casualties that builds up rapidly and extends casualty cycle times. Therefore, the results of Day 2 testing do not support changing the baseline NEHC concept to accept a higher daily casualty rate.

Ranking for Internal Validity - Day 2

Alternative	Utility
1 Expected Results Day 2	100
2 Testing Results Day 2 (2 hrs.)	101
3 Testing Results Day 2 (3 hrs.)	93
4 Testing Results Day 2 (3.5 hrs.)	90

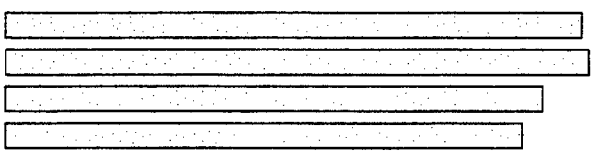


Figure 22: Multiple Criteria Decision Model Results for Day 2

Section

8

8 Alternative Scenarios and External Validity

While the desktop exercise and live field test validated the internal resources, processes and protocols of the NEHC concept in a realistic scenario, the tests were not sufficient to confirm the validity of the concept in other scenarios, nor to confirm its validity as part of the overall MEMS concept.

8.1 Alternative Scenario Exercise

The scenario used for the validation testing was a realistic and possible, if not probable, critical incident involving a non-contagious biological agent. For community emergency planners to have confidence that the NEHC concept will work in the event of a terrorist incident involving BW agents, the concept must be tested in a wider range of situations.

The NEHC simulation model can be used in a desktop exercise to evaluate the performance of the NEHC concept in alternative scenarios. A set of four to five scenarios would be selected that would vary such factors as the symptoms of the BW agent, the casualty-to-worried well ratio, and the severity of the condition of the infected casualties.

8.2 External Validity Testing

The NEHC concept has been shown to provide improved response to a BW incident, but many questions, external to the NEHC remain. How long would it take to establish a working NEHC? How many NEHCs would need to be established? What is the impact of the NEHC concept on the other components of the Modular Emergency Medical System?

These important questions could be addressed using a MEMS simulation model. The purpose of the simulation model would be to establish the desired, or expected, performance of the integrated MEMS components of the BW Response Template, including:

- Acute Care Center (ACC)
- Neighborhood Emergency Help Center (NEHC)
- Casualty Relocation Unit (CRU)

- Community Outreach
- Medical Prophylaxis
- Command and Control EOC

The simulation model could be used to verify the medical care portion of the template before preparation and conduct of integrated template testing in FY 2000. The comparison of integrated test performance to simulated performance would allow the program to assess the validity of the MEMS design. A secondary purpose of the model would be to recommend improvements to the MEMS design. A third potential use of the model is to test alternative assumptions and scenarios, and to assist cities in tailoring template components to their unique situations.

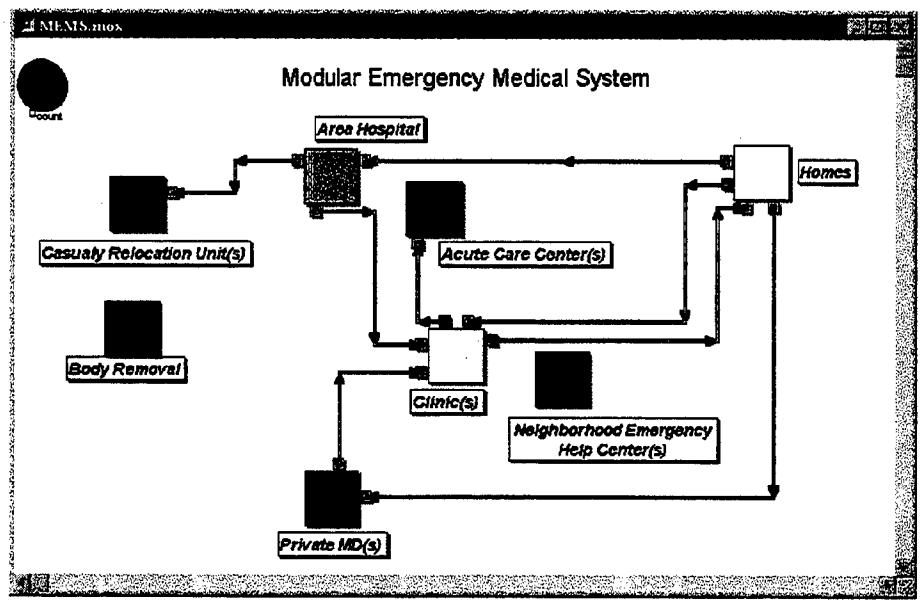


Figure 23: MEMS Simulation Model

The simulation model will help assess the patient capacity of the entire MEMS system and the process of establishing, operating and deactivating multiple ACCs and NEHCs to respond to a BW incident. Measures of Effectiveness (MOEs) may include the percentage of the at-risk population served and the capacity utilization rate. Quality MOEs may include timeliness of deployment and the reduction in mortality and morbidity.

Section

9

9 Conclusions and Recommendations

9.1 Conclusions

NEHC performance was tested via a desktop exercise with an independent panel of emergency medical experts, and a live field test using trained medical staff and actors portraying casualties. The outcomes of these exercises were compared to the simulated performance to validate the design.

The results of the testing provided evidence that the NEHC concept is valid. For the primary scenario (Tularemia) under baseline conditions (1000 presenting casualties per day), the combined test results from the validation panel exercise and the live field exercise provided a high validity score on the measured MOEs. Future exercises to test the robustness of the NEHC concept under alternative scenarios and as part of the entire MEMS portion of the template are planned.

9.2 Recommendations

The Decision Analysis Team recommends the following:

1. The alternative scenarios should be tested to provide full internal validation of the NEHC concept.

2. The external assumptions for the NEHC concept must be validated as part of the integrated MEMS concept.

3. The START protocol used in the Initial Triage area should be reviewed and possibly replaced. This protocol was developed for triage of mass trauma casualties and may not be appropriate for a BW mass casualty incident.

4. The NEHC concept should include a staffing and equipment guide to allow emergency planners to tailor the resources to the specific type of incident, type of building or other factors.

5. The level of care at the NEHC should be decreased. The qualified staff necessary to run an NEHC at the current level of care may not be available once the ACC components are established.

6. A "fast-track" process should be implemented for presenting casualties who may only need first aid or other minor treatment.

7. Family triage and treatment procedures need to be improved and tested.

8. All casualties should be registered upon entry to the NEHC unless the casualty is in an acute presenting condition.

9. The NEHC staff allocations should be reviewed and the staffing needs better matched to the triage and treatment areas.

10. Patient forms need to be redesigned to make them easier to use. The form should fit on a single page, front and back, and should include only the information needed for triage and stabilization treatment.